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PRESIDENTIAL ADDRESS *

BY FRANK D. DICKSON, M.D., KANSAS CITY, MISSOURI

Somewhat conflicting emotions fill my mind as I stand before you to speak as your retiring President. Needless to say, the deepest feeling is one of gratitude to you for the honor you have done me in selecting me for your fourth President, but there is as well a feeling of doubt as to just how successful my stewardship has been and some perplexity as to the form which my address to you should take. The American Academy of Orthopaedic Surgeons is a mere stripling compared to most national organizations with similar aims and purposes; it is in its swaddling clothes with its life all before it; it has but a suggestion of recorded history, and what is to be written in its record depends upon the course followed in the years to come. It would seem, then, that my address must be one of suggestion for the future rather than a review of past accomplishments. I realize that to give advice is often a thankless task and that he who undertakes it is treading on dangerous ground. Therefore, I am not going to give advice, but I shall simply place before you some of the ideas which have occurred to me during the past year on matters which would seem to be important in charting out the course of the Academy on its voyage into the future.

The American Academy of Orthopaedic Surgeons was organized with a specific purpose in mind; according to the second article of our constitution, this was: "To advance orthopaedic surgery in all its phases". This statement is decidedly general in its implications and might wisely be amplified into something more specific. I believe, then, that without attempting to catalogue the purposes of the Academy it might be worth while at this time to enumerate some of the aspirations held by those most interested in its organization. Among these aspirations were: the formation of an organization with nation-wide representation and, therefore, with nation-wide influence in establishing orthopaedic surgery on the

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

plane of importance and dignity which it deserves; the elevation of the standards of education in orthopaedic surgery, both undergraduate and graduate; the encouragement of a systematic study of important orthopaedic problems; the promotion of a close relationship with general surgery, looking toward a freer exchange of information and ideas; and, finally, the establishment of an agency to serve as a competent source of advice and guidance on questions of importance to the public.

If this is a fair statement of the aims of the Academy, it is evident that it has chosen a wide field of activity and that it must be prepared to assume considerable responsibility if these aims are to be attained. Responsibility of this order can only be met by an organization whose membership is of excellent caliber, whose policy is simple and direct, whose deliberations are sound, and whose activities are productive of results which mean genuine advancement in our special branch of medicine. May I then speak with you for a while about some of the things which seem important to me as having some bearing on the carrying out of this rather ambitious program?

Addison has said: "Knowledge is, indeed, that which next to virtue truly and essentially raises one man above another." Knowledge may be briefly defined as the aggregate of facts, truths, and principles acquired or retained by the mind. I stress this word "knowledge" because I believe that it, with ethical standing, should be the hallmark which entitles to fellowship in this Academy. Baer wisely said: "Anatomy, physiology, pathology, physics, chemistry, and biology are the fundamental ingredients which, properly mixed, form the science of medicine." The science of medicine has two great divisions,—medicine and surgery; although closely related, still they are separate designs which together make up the intricate pattern of medicine as a whole. Specialties are but sections of these designs and, taken by themselves, mean nothing; they must fit into the pattern in their proper place. Orthopaedic surgery is probably the broadest and most comprehensive of the special branches of medicine, since it wanders through the entire pattern, appearing now in the design of surgery and now in the design of medicine. The orthopaedic surgeon, then, must have not only information on but knowledge of both medicine and surgery. Steindler has aptly suggested that the proper title should be "orthopaedic physician". The orthopaedic surgeon must have the training and ability to carry out complicated and extensive surgical procedures; he must possess surgical judgment in diagnosis and treatment; and he must be equipped to meet surgical emergencies. He is required to understand pathological changes and physiological and chemical reactions. He should be conversant with medical therapeutics and be prepared to use his knowledge in the management of his cases. Finally, he must have a thorough understanding of function and the means available for restoring function once the pathology has been removed or overcome. This is indeed a wide field and one which demands the broadest of medical training and deep, if not profound, knowledge. I believe that

one of the fundamental requirements for fellowship in this body should be that the candidate measure up to that standard of knowledge which it is necessary that an orthopaedic surgeon possess; otherwise, the prestige of the Academy and, through it, that of orthopaedic surgery everywhere will suffer and one of the important purposes of this Academy will be defeated.

Although it may seem like projecting ourselves into the distant future, a crossing of the bridge before we come to it, I should like at this point to allude briefly to certain influences which are making themselves felt in orthopaedic practice and which seem likely to exercise an even more profound influence upon it in the future, and so upon the future position of this Academy from the point of view of its membership. Until the last decade, the orthopaedic surgeon was largely preoccupied with the care of physical defects of congenital origin or the result of accident or disease in children. During the last ten or fifteen years, an increasingly larger part of his time has been taken up with the treatment of traumatic and occupational injuries. This can only mean that orthopaedic surgery today is gradually, perhaps rapidly, expanding its borders to include traumatic surgery. This change is not surprising since orthopaedic training engenders an attitude of mind and cultivates a familiarity with the use of apparatus which well fit the orthopaedic surgeon to care for the serious and destructive injuries encountered in traumatic surgery. Attractive and lucrative as such practice may be, it cannot be pursued too completely or there is danger that we will lose our sense of proportion and cease to be orthopaedic surgeons and become traumatic surgeons. I would suggest to you, particularly to the younger men, that we must be first, last, and always orthopaedic surgeons; that the effective relief of the physically handicapped is the real justification for our existence as a specialty; that we do not lose sight of the fact that it has been our training as orthopaedic surgeons which has been responsible for any proficiency which we may have in treating traumatic cases, not the reverse; and, finally, that a good traumatic surgeon does not necessarily signify a capable orthopaedic surgeon. Sooner or later, our membership will have to make a decision as to what extent orthopaedic surgery and traumatic surgery can be mixed. We may perhaps be called upon to set up a dividing line and we should be giving some attention to this question in order that mature thought may insure a wise decision.

Probably the most important single influence in determining the course which a medical student will follow after graduation is the quality of his undergraduate instruction. It would seem, then, that the Academy should be deeply interested in the kind of orthopaedic training which the students of medicine are receiving to-day and which they are to receive in the future. This applies not only to those who are aiming toward eventually taking up orthopaedic surgery as their life work, but also to all who intend to practise medicine. No course in the medical curriculum can be of greater service to the practising physician than one which gives

him a working knowledge of the orthopaedic problems, since they are of relatively frequent occurrence in general practice. The Academy has set up as one of its requirements for fellowship that the candidate shall have had adequate training in orthopaedic surgery. What constitutes an adequate training? Hitherto it has meant that the applicant has been associated with a recognized orthopaedic surgeon or has taken postgraduate work for a period of time and has gained approval by the quality of his work. Is this not perhaps a rather loose standard, since it by no means gives assurance that the training has been well-rounded and complete enough to fit the individual to meet adequately all the demands which may be made upon him? Should not the Academy outline a course of postgraduate study along flexible lines which would be comprehensive enough to be acceptable as adequate training, and require that those who offer postgraduate courses or training follow this plan? The American Orthopaedic Association has a Committee on Undergraduate Instruction in Orthopaedic Surgery which has made a careful study of orthopaedic instruction and a year or two ago submitted a report. What has been accomplished toward putting into effect the recommendations of this Committee I am unable to say, but I question whether the acceptance of its proposals has been wide-spread. Certainly, if it is to carry out the spirit of its stated purpose, this Academy should join actively with other interested bodies not only in planning but also in putting into effect adequate orthopaedic teaching; yet in our list of standing committees there is no Committee on Medical Education. This omission should be remedied and a strong and active committee be formed to deal with this important subject.

Closely related to orthopaedic instruction in establishing a reasonable proficiency in orthopaedic practice is the need for some sort of standard for determining the fitness of the aspirant desiring to practise orthopaedic surgery as a specialty. There has been established under proper authority the American Board of Orthopaedic Surgery, which has been granted the right to issue certificates of proficiency or approval. Is it not most desirable that all Fellows of the Academy should hold certificates from this Board and that in the near future the requirements for fellowship should include such certification? Certainly, the Board should have the endorsement and support of the Academy, and such approval can be expressed only in this way.

I believe that the purpose most generally stressed in the discussions which led to the formation of the Academy was the part it might play in fostering the investigation of medical problems in the solution of which orthopaedic surgeons might be expected to provide leadership. It was felt that an active and wide-spread membership would provide opportunities for collecting data on the results of treatment from many sources and that this material, when assembled and studied by committees of the Academy, would allow important and helpful conclusions to be drawn which would be far more authoritative than the observations of individual

workers. That the Academy has made an excellent start in this direction is evidenced by the fact that this year symposia arranged by two committees are appearing as part of our program. There are, however, many avenues of investigation along which the Academy must press if it is to hold up its end in medical progress. For me to attempt to indicate the paths which such investigations should follow would be presumptuous. I would merely suggest a few which have occurred to me, such as an evaluation of the newer operations for stimulating or retarding bone growth, additional inquiry into the operations on the sympathetic system for the relief of spasticity and to increase growth in paralyzed limbs, and a study of the endocrine system not only in relation to important bone conditions but as to the effects of endocrine imbalance on developmental and postural problems in growing children. If these suggested lines of inquiry and a host of others which will readily occur to you fall within the scope of the Committee for Scientific Research, I hope that this Committee is actively engaged upon plans for forwarding them; if not, then I suggest that this Committee be enlarged so that it may do so, since help in arriving at sound conclusions on newly suggested and incompletely tested facts should be one of the vital activities of this Academy.

The relation which orthopaedic surgery bears to general surgery is a very close one. Orthopaedic surgery is a subdivision of general surgery and, no matter how strong and robust we may believe ourselves to be, we cannot divorce ourselves from general surgery, nor should we desire to do so. There should be the closest unity between the general surgeon and the orthopaedic surgeon and the freest interchange of ideas, since both are working for the same purpose,—restoring the ill and the disabled to health and usefulness. One of the wisest of those who have served the interests of orthopaedic surgery, the late Nathaniel Allison, constantly cautioned against orthopaedic surgery's isolating itself, since such isolation inevitably leads to narrowness and loss of vitality and progressiveness. Let us keep our contacts with general surgery and even draw them closer; it will help both the general surgeon and ourselves. The Academy has indicated an appreciation of the advantage of such an alliance by providing for Associate Members who need not be Simon-pure orthopaedic surgeons. If judiciously chosen, the Associate Membership should be a very vital part of our Academy.

In these days of change, social upheaval, and very articulate demands for social security, there seems to be a growing desire for some form of altered relationship between the medical profession and its patients, the public. There has been a regrettable lack of interest displayed by the individual members of the profession in this very important and live subject, so that apparently the responsibility of shaping the many unsound and unworkable theories put forward for its solution into some workable and responsible plan must devolve upon organized medical bodies. The American Medical Association and the state and county medical societies are becoming more and more alive to the necessity of medical leadership

in shaping these plans. The orthopaedic case has aspects which demand plans differing in detail at least from those which fit the general run of medical and surgical cases and it would seem important that our Committee on Legislation and Medical Economics be prepared to make its voice heard in formulating these plans when the opportunity presents itself. Even more important, however, is the individual responsibility of the large and wide-spread membership of the Academy to interest itself locally in both general medical economic planning and the particular planning which has to do with the care of the physically handicapped. In this way, and in this way only, can the Academy fulfill its obligation to the public and provide that leadership which the public has a right to expect of us.

Since I have wandered so far afield and, contrary to my stated intentions, have ventured to give what sounds suspiciously like advice, I will go all the way and mention before closing one other impression which has been growing upon me in recent years, since it concerns a matter on which the Academy should take a definite position. I mean the tendency toward what might be termed the mechanization of orthopaedic practice. One cannot but be impressed by the bewildering array of splints, wires, pins, traction apparatus, and gadgets of all sorts which have been recommended or have come into use in the past few years for the correction of deformity and reduction and splinting of fractures. At the risk of being considered old-fashioned or reactionary, I must express the hope that this Academy will see fit to take a position in its deliberations which will suggest a "breathing spell" in the introduction of mechanical devices, so that we may allow ourselves time to evaluate properly the place in orthopaedic practice of those already in use. This evergrowing increase in the use of mechanical contrivances and the dependence upon them seems to carry with it some very real dangers,—namely, the tendency to rely upon a mechanism to do the work for us instead of doing it ourselves; the fostering of a lack of exactness in clinical examination and of meticulous supervision, so important in the management of a case; the encouragement of a belief that mechanical devices can alter or hasten healing instead of merely, at the best, supplying a more efficient mechanical support; and, finally, the likelihood that the inexperienced and insufficiently trained individual, by relying upon a mechanism to make up what he himself lacks, may be encouraged to undertake the treatment of conditions he is unfitted to care for. I would not be understood as undervaluing mechanical aids, many of which have been of the greatest service and are indispensable to efficient treatment, or of desiring to obstruct progress. I would merely warn against the too ready acceptance of every new device suggested until a careful study has shown that it is mechanically right and that its use is based on sound physiological principles. It would not be inconsistent for the Academy to take the position that it is incumbent upon those who seek to replace an accepted method of treatment by a mechanical device that they show that the method they propose will greatly diminish or

altogether prevent the failures of the method they seek to supplant. Stated in another way, we should require that their work be tested by results as well as theory and intentions before acceptance.

This address has been prolonged far beyond the limits originally set and must be brought to an end. If I have been overinclined to impose upon you my personal views, it has been because there seemed no other way to bring to your attention matters touching the future policy of the Academy which appear to be important, judged in the light of my experience as your President during the past year.

In closing, I should like to express to you my conception of the position in which the Academy finds itself after three years of activity and very rapid growth. The American Academy of Orthopaedic Surgeons has been safely launched; it has started on what promises to be a most successful voyage; its future is in your hands to do with it what you will. While its destiny is beyond our powers to envision, there is no doubt in my mind that in the years to come it will build up a record of service and usefulness commensurate with the high aspirations of those who conceived it, always provided that it charts a true course, setting up as its beacons those honorable and unselfish precepts laid down almost fifty years ago by that splendid group of men who founded the specialty of orthopaedic surgery.

OPERATIVE RECONSTRUCTION OF MALUNITED FRACTURES ABOUT THE ANKLE JOINT *

BY J. S. SPEED, M.D., AND H. B. BOYD, M.D., MEMPHIS, TENNESSEE

Malunion following the usual bimalleolar fracture (Pott's type), or the trimalleolar fracture of the ankle (Cotton's type), occurs not infrequently, even in the hands of those experienced in the treatment of these fractures. The ankle is a weight-bearing joint, hence even minor disturbances in the relation of the articular surfaces or distortion of the weight-bearing alignment of the joint may produce serious and persistent dysfunction. After these fractures have become partially or completely united, further closed manipulation is usually inadequate and may be disastrous. In consequence, some type of open operative reconstruction is required for the relief of the disability.

There is little available material in the literature to guide one in the choice of operative procedure to be employed for the correction of the various deformities. While each case is an individual problem and no set rules can be applied to any group, it was felt that a study of a series of these reconstruction operations might lead to more definite conclusions as to which procedures were most practical, and might indicate the type of reconstruction which has given the best functional results in each group as a whole.

The following report is based on a study of some fifty operations of various types for malunited fractures about the ankle. The procedures employed are described and an attempt is made to estimate their value by the functional results obtained. A thorough knowledge of the anatomy of the ankle joint, including the relation of the articular surfaces to the ligamentous supports, is essential to the proper conception of the problems involved in deciding on the type of reconstruction operation to be employed. The ligaments and bony structures which compose the ankle joint have been previously described in many articles; therefore, such a description will not be included in this study. It should be remembered, however, that, due to the ligamentous attachment between the lower end of the fibula and the astragalus, these two bones generally move as one in displacements following fractures about the ankle. The posterior tibiofibular ligament joins the lower end of the fibula to the posterior surface of the tibia; consequently, in fractures of the posterior margin of the tibia, the detached tibial fragment usually follows the fibula.

There are three definite requirements which a reconstruction operation must fulfill in order to preserve motion in the ankle:

1. Restoration of the proper weight-bearing alignment of the leg as a whole;

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2. Restoration of the normal anatomical relationship between the articular surfaces of the tibia and the astragalus;

3. Restoration of a satisfactory range of painless motion.

Experience has shown that, if these requirements are not fulfilled, unsatisfactory functional results are obtained in a high percentage of cases. It is desirable in all cases, where possible, to preserve motion in the ankle joint and every effort should be made to attain this end. A study of the end results in this series of reconstruction operations has shown that in certain types of malunited fractures, particularly the trimalleolar (Cotton's fracture), efforts to preserve motion in the ankle joint have resulted in poor function in approximately 75 per cent. of the cases. Consequently, a more radical type of reconstruction, such as a fusion of the ankle, should be considered as a primary procedure in the more severe types of fractures or in cases of long standing.

The combined operative and manipulative traumata should not be so excessive as to fracture the articular surfaces or to damage them so that traumatic arthritis is the inevitable end result. A stiff, painless ankle is much more serviceable than one with limited, painful motion.

For convenience of description, these fractures have been divided into two groups: first, fractures of the internal and external malleoli, or the Pott's type of fracture; second, fractures of the internal and external malleoli combined with fractures of the posterior margin of the tibia, the trimalleolar or Cotton's type of fracture.

Pott's Type of Fracture

A study of the results in this group has shown that the conservative types of reconstruction operations which preserve motion in the ankle joint have proved satisfactory in the majority of cases and should be used as the primary procedure in most cases. Where this type of operation fails to correct the deformity, or where subsequent traumatic arthritis with persistent disability occurs, a fusion of the ankle should be employed as a secondary procedure.

The simplest type of fracture at the ankle is the eversion fracture, involving the lower end of the fibula without fracture of the internal malleolus. Where lateral displacement occurs, the deltoid ligament is, of necessity, partially or completely ruptured, which allows the astragalus to be displaced laterally with the fibular fragment. Following reduction of the fracture, valgus deformity is not uncommon because the internal anchorage normally afforded by the deltoid ligament has been lost.

In this type of fracture, where there is malunion with valgus deformity, the reconstruction is relatively simple. An osteotomy of the fibula, followed by manipulation, will usually effect a correction. Occasionally, the space between the internal malleolus and the astragalus is filled with scar tissue which must be excised before the astragalus can be approximated to the internal malleolus. If the ankle is held in the corrected position by postoperative immobilization sufficiently long for

FIG. 1-A

The typical malunion of a bimalleolar Pott's fracture.

FIG. 1-B

Result after usual reconstruction operation, showing correction of the deformity by bimalleolar osteotomy and lengthening of the tendo achillis. Correction in these cases is facilitated by thorough mobilization of the external malleolus.

complete and solid union to occur in the fibula, it is usually unnecessary to repair the deltoid ligament.

The second in this group is the bimalleolar fracture in which union has taken place with lateral and posterior displacement of the astragalus (Fig. 1-A). The operative correction here depends on thorough mobiliza-

tion of the external malleolus to permit correction of the fibular shortening and the external rotation of the lower fibular fragment. The pro-

FIG. 2-A

Eversion type of Pott's fracture in which the tibial fragment includes the whole lower end of the tibia, united in valgus deformity. The relation of the joint surfaces is not disturbed. This is an ideal type of case for supramalleolar osteotomy.

FIG. 2-B

Excellent anatomical and functional result following reconstruction by supramalleolar osteotomy.

cedure allows the astragalus to move forward and to rotate medially, thus restoring the normal relationship between the articular surfaces of the astragalus and the tibia. The increased length of the fibula corrects the valgus deformity. An osteotomy of the internal malleolus should be done in those cases where it is solidly united in malposition. This osteotomy is done preferably through the medial portion of the tibia, just above the old line of fracture in the internal malleolus, as this site gives a broader osseous surface for union. In cases where the fracture of the fibula has occurred two or more inches above the ankle joint, it is preferable to do an osteotomy through the old fracture line, which restores the normal fibular length at the site of the old fracture. This is possible in the recent cases before scar tissue has organized. In cases of longer duration, such a procedure does not permit sufficient mobilization of the lower end of the fibula. In these cases, an oblique osteotomy of the fibula at the joint line allows lengthening of the fibula and also sufficient mobilization to effect correction of the deformity. In addition to the bimalleolar osteotomy, lengthening of the tendo achillis is necessary when there is an equinus deformity.

In fractures which have united with a valgus deformity, but in which the normal relationship between the articular surfaces of the tibia and astragalus has not been materially changed, a supramalleolar osteotomy may be the operation of choice. Here an osteotomy of the tibia is done well above the joint line at the position which appears best suited to correct the angulation. A corresponding osteotomy of the fibula is performed at the desired level. The valgus deformity can then be corrected and the normal weight-bearing alignment of the foot and ankle can be restored without an extensive operation on the soft structures about the ankle joint proper. The execution of this procedure is much easier and possible damage to the articular surfaces of the ankle joint is obviated.

The supramalleolar osteotomy is the ideal operation to use in the rare cases which Ashhurst has classified as type-three eversion fractures, where, instead of the usual fracture of the internal malleolus, the fracture line extends across the entire lower end of the tibia just above the joint surface (Fig. 2-A). In these cases, there is little disturbance in the relationship between the articular surfaces of the ankle joint. The valgus deformity is due to angulation at the fracture site and is easily corrected by a suitable osteotomy at this point. The results in all cases of this type have been excellent. (See Figure 2-B.).

The supramalleolar osteotomy should be reserved for those cases in which the valgus deformity is associated with a relatively normal relationship between the articular surfaces of the tibia and astragalus. In order to avoid extensive surgery about the ankle joint proper, in one case of Pott's fracture in this series, an effort was made to restore function by simply correcting the valgus deformity and restoring the weight-bearing alignment by a supramalleolar osteotomy. The altered relationship

FIG. 3-A

Pott's fracture with valgus deformity and disturbed relationship between the articular surfaces of the tibia and the astragalus.

FIG. 3-B

Result of reconstruction operation in which the weight-bearing alignment of the leg was restored by correction of the valgus deformity and the altered relationship between the articular surfaces of the ankle joint was disregarded. The functional result was unsatisfactory, illustrating the fact that restoration of the normal relationship between the articular surfaces is just as important as correction of the weight-bearing alignment.

FIG. 4-A

Malunion of Pott's fracture of long standing with distortion of the joint surfaces and traumatic arthritis, resulting in persistent disability. Fusion of the ankle is indicated as a primary procedure in this type of case.

FIG. 4-B

Postoperative result of fusion by the posterior approach.

between the articular surfaces of the astragalus and the tibia was disregarded. A very satisfactory correction of the weight-bearing alignment of the leg as a whole was secured, but the joint remained painful and func-

tion was not improved because of the persisting disturbance in the relation of the joint surfaces. This case illustrates the fact that restoration

FIG. 5-A

Malunion of the simplest type of Cotton's fracture. The posterior fragment is very small; therefore, enough of the articular surface of the tibia remains to insure stability of reduction.

FIG. 5-B

Result of reconstruction operation in which osteotomy of the fibula, lengthening of the tendo achillis, and manipulation to correct the valgus deformity were sufficient to restore the normal relation of the joint.

FIG. 6-A

Typical trimalleolar fracture, with large posterior fragment, in which posterior dislocation of the astragalus recurred during immobilization in a cast. In such a case, open reduction, with some means of internal fixation, is necessary to prevent further recurrence of the deformity and a type of malunion which is difficult or impossible to reduce later.

FIG. 6-B

Ten weeks after injury, showing result of open reduction and internal fixation. Normal function has been restored.

of the proper relation of the articular surfaces is just as essential as correction of the weight-bearing alignment (Figs. 3-A and 3-B).

Cotton's Type of Fracture

In this group of trimalleolar fractures, reduction is more difficult and it is harder to maintain the fragments in position at the time of the fracture; consequently, malunion occurs relatively more frequently. This is due to the fact that the support of the posterior malleolus, often including as much as one-half of the articular surface of the tibia, is displaced. This fragment is firmly attached by ligaments to the astrag-

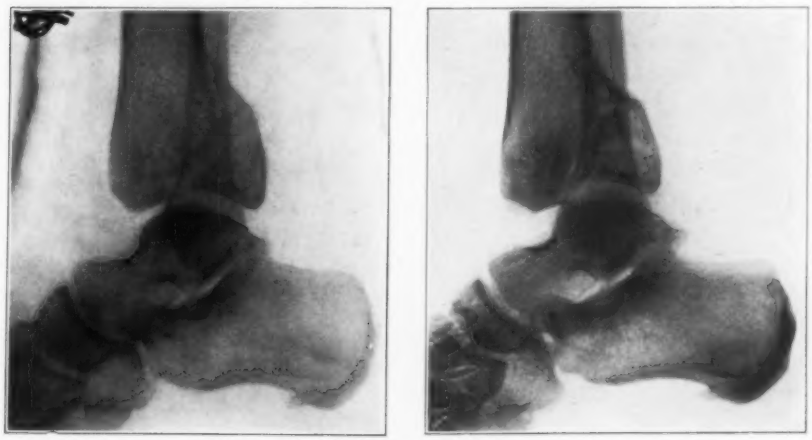


FIG. 7-A

Satisfactory closed reduction of a typical trimalleolar fracture, followed by recurrence of deformity and malunion with severe dysfunction. A reconstruction operation was done at the end of one year. Extensive operative procedure was necessary to correct the deformity.

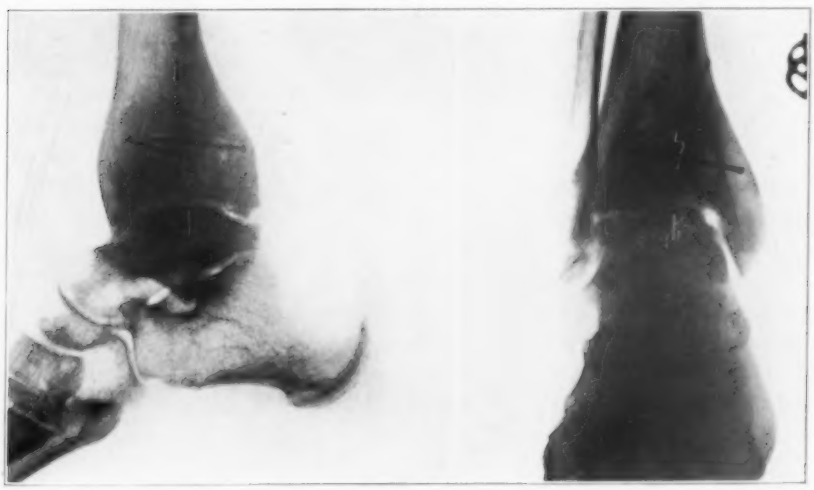


FIG. 7-B

Result five years after reconstruction: deformity corrected and fragments united in good position. The result was unsatisfactory because of extensive degenerative arthritic changes in the joint. Fusion of the ankle was advised for relief of the disability.

alus and external malleolus. Thus, in the deformity the three move together, posteriorly and upward as well as laterally. Where as much as one-third of the articular surface is included in the posterior fragment, the foot must be placed in equinus to secure reduction. Efforts to pull the posterior fragments down by strong dorsiflexion of the foot result only in posterior displacement of the astragalus and further upward displacement of the posterior fragment. With the foot in a cast, in the position of equinus, the recurrence of the posterior displacement of the astragalus is not infrequent. Because of this possibility, frequent postoperative examinations, by means of roentgenograms taken through the cast, are necessary. If the deformity is found to have recurred, a definite plan of action should be instituted in order to prevent malunion, the correction of which is extremely difficult or impossible. If the recurrence of the deformity is discovered in the first three or four weeks after reduction, a satisfactory reposition of the fragments may be obtained by open reduction, using some means of internal fixation to hold the posterior fragment in position. Further attempts at closed manipulation usually are unsuccessful in restoring the posterior fragment to proper position. If, by good fortune, proper reduction is obtained, no further safeguard has been added to prevent another recurrence of the deformity. Open reduction, then, is indicated when the fracture cannot be satisfactorily reduced at the time of the original manipulation or when the deformity has recurred during immobilization. Some type of internal fixation, such as a nail or screw, should be used to hold the posterior fragment in its proper position. The results following this plan of treatment have proved satisfactory. (See Figures 6-A and 6-B.) It is true that in any individual case the fragments may be remanipulated and their position maintained. Taken as a class, however, fewer cases of malunion will occur in this group of fractures if open reduction and some type of internal fixation are used.

When definite malunion has occurred in trimalleolar fractures, reconstruction operations which attempt to preserve motion in the ankle joint are always difficult and frequently impossible. The difficulty depends largely upon two factors: first, the size of the posterior fragment; second, the extent of the organization of the scar tissue and the amount of osteoporosis of the bone. When the posterior fragment is small and there is very little posterior displacement of the astragalus, the same operative principles which govern the treatment of Pott's fractures may be employed. In such a case, the displacement of the posterior fragment can usually be corrected by the usual procedures employed to correct the lateral displacement and external rotation. In cases where the posterior fragment is small, there is enough of the articular surface of the tibia left to insure the stability of the reduction.

In the typical trimalleolar fracture with malunion, where the posterior fragment includes as much as one-third to one-half of the articular surface of the tibia and where the astragalus is displaced posteriorly, the reconstruction operation becomes much more difficult. Correction of the

valgus and external rotation offers no more difficulty than in the usual Pott's fracture. The real difficulty is found in mobilizing the displaced posterior fragment and in bringing the astragalus forward to its normal position under the articular surface of the tibia. The firm organization of scar tissue and the contracture of the posterior capsule and the tendo achillis hold the astragalus firmly in its position of posterior displacement. Even after extensive loosening of the soft tissues and ligaments about the ankle joint, including incisions on the inner and outer sides of the ankle and lengthening of the tendo achillis, strenuous manipulation is necessary to push the astragalus forward. The combined dissection and manipulation procedures are often sufficient to damage the joint surfaces, resulting in traumatic arthritis which impairs future function, even though the deformity may be corrected. The following case illustrates such a result.

The patient was first seen with an acute trimalleolar fracture which had been satisfactorily reduced, but in which the deformity had recurred during immobilization in a cast (Fig. 7-A). Because of other complicating injuries, further treatment of the fracture was impossible and malunion occurred, with slight upward displacement of the posterior fragment and posterior displacement of the astragalus. A reconstruction operation was done one year later, at which time the displacement of the astragalus was corrected and the posterior fragment was brought down into its normal position, where it was held until solid union took place. Pain, swelling, and disability in the ankle persisted. Further roentgenograms (Fig. 7-B), five years after the reconstruction operation, showed a good anatomical correction of all the deformities, but sufficient degenerative changes in the articular surfaces of the ankle joint to impair function seriously. Because of the persistent disability, a fusion of the ankle was advised at this time.

In other cases where the difficulty of correction of the posterior displacement of the astragalus is realized and every effort is made to accomplish it by wide exposure of the joint and thorough excision of the contracted scar tissue, combined with the usual osteotomies of the malleoli, it is impossible to obtain a satisfactory operative correction of the deformity. These incomplete conservative operations have universally proved unsatisfactory. In consequence, when such difficulties are encountered during the operative procedures, it is better to fuse the ankle joint than to attempt to preserve ankle motion.

Excessive manipulative force should be avoided in attempting to overcome the deformity in these resistant cases. Further crushing or fracturing of the joint surfaces may occur. This is especially true where osteoporosis is present. In 75 per cent. of the cases of this type in the present series, conservative reconstruction operations resulted in such poor function that fusion operations would obviously have been the better procedure.

One case in this series was particularly instructive, as it not only showed the difficulties and dangers which accompany the usual conservative reconstruction operation, but it also suggested the means of overcoming these difficulties.

In this case there was a malunited trimalleolar fracture with both lateral and posterior deformity. Moderate osteoporosis was present. A conservative reconstruction

FIG. 8-A

Trimalleolar fracture with malunion of nine months' duration. Moderate osteoporosis was present.

FIG. 8-B

Condition immediately following reconstruction operation. After bimalleolar osteotomy, lengthening of the tendo achillis, and freeing of the soft tissues, considerable manipulative force was still necessary to correct the deformity. This resulted in crushing and comminution of the remaining articular surface of the tibia. The functional result was poor at the end of one year.

operation was attempted. Great difficulty was experienced in trying to mobilize the posterior malleolus and to bring the astragalus forward to its normal position. Only moderate manipulative force was used, but this resulted in crushing and comminution of the remaining articular surface of the tibia. Both the lateral and posterior deformities were finally corrected

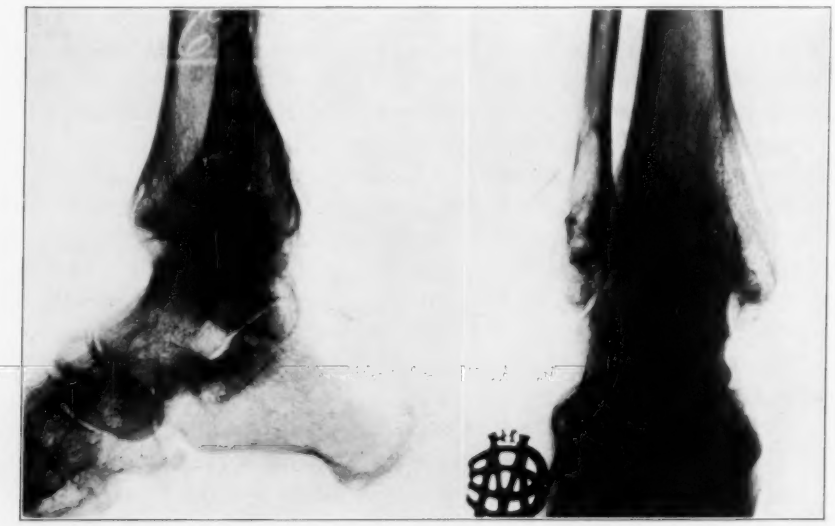


FIG. 8-C

Condition five years after reconstruction operation: spontaneous fusion in good position, followed by a good functional result.

FIG. 9-A

Malunion of trimalleolar fracture, with inability of the patient to walk on the foot at the end of eight months.

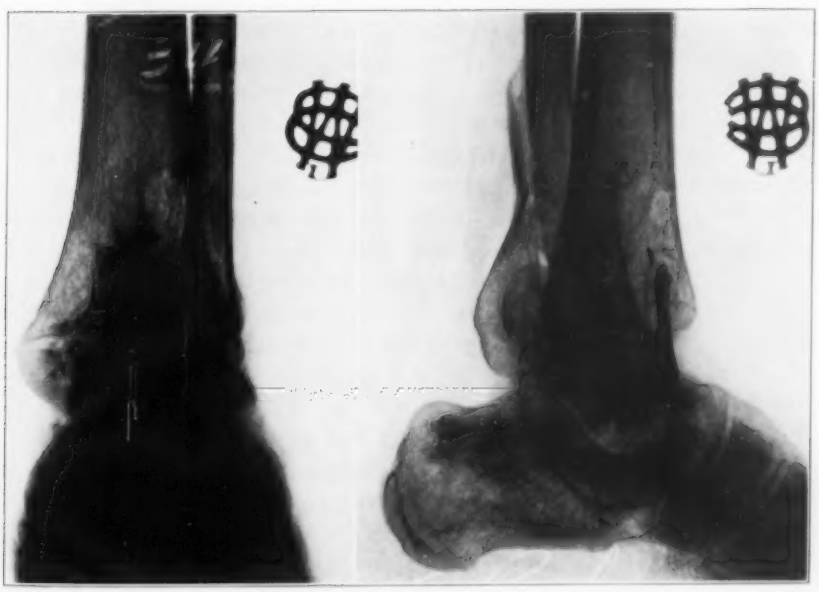


FIG. 9-B

Result following primary fusion of the ankle by anterior approach: satisfactory correction of the deformity and good functional result. This illustrates the type of fracture in which primary fusion of the ankle is indicated.

and the fracture united in good anatomical alignment. Pain and disability persisted and the patient was using crutches at the end of a year, at which time she disappeared from observation. At the end of four years, she returned, stating that her ankle gave her very little pain and that she had excellent function. Roentgenograms revealed a spontaneous fusion of the ankle in good position. An examination of the foot showed the development of excellent compensatory motion in the midtarsal and subastragalar joints.

Here nature had intervened and had provided a solution which should be a guide to the surgeon in the treatment of similar cases. (See Figures 8-A, 8-B, and 8-C.)

FUSION OF THE ANKLE

Experience has shown that for conditions other than malunited fractures, such as tuberculosis, fusion of the ankle has given good functional results. The same results may be obtained by this method in the treatment of malunited fractures in which conservative procedures have failed or in those cases in which experience has shown that a high percentage of poor results follows conservative reconstruction.

A study of the end results in the two groups of cases described has led to definite conclusions regarding the indications for primary fusion of the ankle rather than attempts at conservative reconstruction.

Fusion of the ankle is indicated as a primary procedure in the following types of cases:

1. Pott's fractures, with or without deformity, in which the roentgenograms demonstrate definite arthritic changes, with roughening or distortion of the joint surfaces, resulting in persistent pain and disability.
2. Malunited trimalleolar fractures of long duration, with posterior dislocation of the astragalus and upward displacement of the posterior malleolus.
3. Cases in which, during the course of attempted conservative reconstruction for any of the types of malunion, it is found that the deformity cannot be corrected, or that such extensive operative procedures are necessary or such excessive manipulative force is required that subsequent degenerative changes in the ankle joint appear inevitable.
4. Rare cases of malunion following fracture of the anterior lip of the tibia and forward displacement of the astragalus.

Operative Technique

Fusion of the ankle may be accomplished through either the anterior or posterior approach. A fusion by the posterior route was originally designed as an extra-articular procedure to be employed in such conditions as tuberculosis. In fusion by the posterior approach, the tendo achillis is divided and the back of the ankle joint is exposed. The posterior surface of the tibia is denuded and an arthrodesis of the subastragalar joint is done. Bone chips are then turned up from the os calcis and down from the tibia to bridge completely the denuded area between the os calcis and the tibia.

In fusion by the anterior route, the joint is exposed by an incision over the anterior surface of the ankle, just lateral to the extensor tendons. The anterior surface of the joint is thoroughly exposed, giving a clear view of both internal and external malleoli. The astragalus and the tibia are denuded of articular cartilage and sufficient bone is removed to provide an unobstructed view of the entire ankle joint. When present, lateral deformity is corrected by osteotomy of the fibula and mobilization of the external malleolus. If necessary, the tendo achillis is lengthened to correct the equinus deformity. If difficulty is still encountered in bringing the astragalus forward to its proper position, further dissection of the soft tissues, often including division of the posterior capsule, is done. The articular cartilage is next removed from the internal and external malleoli. The astragalus is then brought into position, correcting both the posterior and lateral deformity. A graft, two and five-tenths by five centimeters, including the entire thickness of the cortex, is next removed from the anterior surface of the tibia. This graft is dropped down across the joint and countersunk into the neck of the astragalus. The leg is immobilized in a plaster cast, with the foot in the position of slight equinus without inversion or eversion. It is felt that slight equinus is desirable, particularly in women, to allow for the heel of the shoe.

Fusion by the anterior route has certain distinct advantages over that by the posterior approach. The anterior approach permits a wider exposure of the important structures in the operative field and gives a clearer view of the joint after correction has been obtained. It allows a complete denudation of the joint surfaces and facilitates the removal of sufficient bone from the tibia and the astragalus to correct the posterior displacement. It does not sacrifice motion in the subastragalar joint. When the astragalotibial joint is fused, the compensatory motion afforded by the subastragalar joint is extremely useful in permitting sufficient lateral mobility to enable the patient to walk over rough ground. The anterior approach has the disadvantage of requiring a second incision when lengthening of the tendo achillis is necessary.

Clinical Application

Primary fusion of the ankle was considered to be indicated and was performed in eight cases of this series. It was advised as a secondary procedure in five cases in which the results were unsatisfactory following the more conservative type of reconstruction operation. The results following fusion of the ankle for malunion have been most gratifying. The patients have complained of some difficulty in walking over rough ground, especially those whose ankles were fused by the posterior approach; otherwise, the joints have satisfactorily withstood the functional demands of ordinary use.

CONCLUSIONS

1. The majority of malunited Pott's fractures can be satisfactorily

corrected by conservative operations which preserve motion in the ankle joint.

2. In acute trimalleolar fractures (Cotton's type), an open operation should be done when it is impossible to secure satisfactory position at the original manipulation or when the deformity recurs during immobilization. In performing such an operation, it is preferable to use some type of internal fixation for the posterior fragment.

3. In cases of malunion following trimalleolar fractures of the more severe types or of long duration, conservative reconstruction operations result in a high percentage of poor functional results.

4. Fusion of the ankle is indicated as a primary procedure in certain types of malunion where experience has shown that conservative reconstructions are unsatisfactory.

5. Fusion of the ankle is indicated as a secondary procedure in those cases of malunion where a more conservative type of reconstruction has failed.

PROGNOSIS AND TREATMENT OF TUBERCULOSIS OF THE BONES OF THE FOOT

BY LEO J. MILTNER, M.D., AND H. C. FANG, M.D., PEIPING, CHINA

From the Division of Orthopaedic Surgery, Department of Surgery, Peiping Union Medical College

The prognosis and treatment of tuberculosis of the bones of the foot, as well as of tuberculosis of other parts of the skeleton, are governed largely by three factors: the age of the patient, the type and duration of the disease, and the social status of the patient.

In childhood, it is generally conceded that the prognosis is favorable with conservative treatment if such treatment is carried out consistently and proper attention is given to the usual hygienic measures, special emphasis being placed on heliotherapy and immobilization. Occasionally, minor operations—such as the laying open of a sinus or the excavation of an isolated focus in a single bone—are justified, but radical procedures—such as the removal of one or more tarsal bones or the amputation of the extremity—are rarely called for, except in the most advanced cases. Humphries and Durham reported the end results of conservative treatment in twenty-nine patients whose ages averaged five and one-half years at the beginning of treatment. The average duration of treatment was four and one-sixth years. Twenty-three patients were cured: fifteen obtained full function and eight, partial function.

In 1910, Sever published the results of a study of the cases of tuberculosis of the ankle joint and foot seen at the Children's Hospital, Boston, from 1868 to 1910. He concluded that in children conservative treatment is better than operative treatment, since it causes less secondary joint involvement and other spread of the disease and results in more satisfactory healing and a greater degree of function of the joints. Fitzsimmons studied the subsequent cases (1910–1920) at the same institution and arrived at similar conclusions.

Rollier and Lo Grasso treated both children and adults conservatively and obtained an ultimate cure in 90 per cent. of the cases. Three-fourths of these patients acquired normal function and the remainder, partial function.

Most reports of adult patients show comparatively poor results from conservative treatment. Jones, Murphy, Hibbs, Brackett, Gaenslen, Geist, and many others have advocated, particularly in elderly individuals, early fusion of the involved joints, excision of the tuberculous tissue, or arthrectomy. McGavin, Cotton, Chiari, and Calvé also place emphasis on surgical treatment in adults. For the early cases, they recommend extensive tarsectomy and for the advanced cases, amputation. Most authors condemn simple curettage, contending that, since all of the diseased tissue is not removed, healthy areas are opened for fresh infection.

McGavin makes an exception by advocating curettage for localized lesions of the smaller tarsal bones such as the cuboid and scaphoid.

In the selection of a method of treatment in individual cases, the social status of the patient should be considered carefully. This is especially true in countries such as China where approximately 90 per cent. of the patients are too poor to afford long periods of conservative management and where, through difficulties imposed by the distance of the patients' homes from a hospital and lack of education, the disease is likely to be far advanced before treatment is sought. In a high percentage of our cases, when the patients presented themselves for treatment, the feet showed marked swelling, infiltration of the soft tissues, and draining sinuses. Many of these patients were malnourished and showed active tuberculosis in other parts of the body. Therefore, radical operations, particularly amputation, were frequently required. Often amputation was called for simply because it was necessary that the patient be returned to work at the earliest possible time, whereas more conservative surgical management would otherwise have been clearly indicated.

There are two main types of tuberculous disease of the foot, each having certain characteristics which are determined by the reaction of the tissue in which the infection is located. If the local lesion begins in the synovial tissue or surrounding soft tissue, the infection is liable to spread widely by direct extension through several of the joints. This is the infiltrating type which gradually involves one or more of the bones and presents early the clinical symptoms and signs of inflammation, such as pain, tenderness, local heat, and swelling. When the lesion starts in the central portion of one of the bones, the patient may complain only of a dull aching pain for several weeks or even several months. If untreated, this latter type of lesion extends gradually through the cortex to involve the proximal joints and bones. When the cortex has been perforated, the disease may assume the clinical nature of the infiltrating or synovial type.

The following statistics and comments are concerned chiefly with the results of surgical treatment in a wide variety of tuberculous lesions of the foot. Most of the lesions were relatively well advanced before the patients came to seek relief and, therefore, our results should be evaluated separately from those of clinics in other countries where the social conditions are better and where the disease is no longer as severe in its manifestations or as prevalent as it is in China. In practically all of our cases there were indications for early surgical treatment, particularly amputation. However, by means of radical excision of the diseased soft tissue and bone, we were able to eradicate the local disease and to save a useful portion of the foot in 20 per cent. of these cases. In this report, we wish particularly to emphasize the indications for the latter procedure.

STATISTICS OF TREATMENT

From 1920 to 1934, 147 cases of tuberculosis of the bones of the foot were examined in the Peiping Union Medical College Hospital. Active

TABLE I

DISTRIBUTION OF CASES ACCORDING TO AGE GROUPS

Age Group	Males		Females	
	No. of Cases	*Per Cent.*	*No. of Cases*	*Per Cent.*
1–5	2	2.2	0	0.0
5–10	3	3.3	9	15.8
10–20	26	28.9	26	45.6
20–30	50	55.6	12	21.1
30–40	5	5.6	8	14.0
40–50	2	2.2	2	3.5
50–60	2	2.2	0	0.0
Total	90	100.0	57	100.0

treatment was instituted in 129 of these cases. Of the eighteen untreated cases, there were: eight in which treatment was not instituted because of a very advanced or terminal stage of associated pulmonary tuberculosis; seven in which treatment was refused by the patient; one in which death

TABLE II

OCCURRENCE OF TUBERCULOSIS IN BONES OF THE FOOT

Bone Involved	Single Lesions		Multiple Lesions		Single and Multiple Lesions Combined	
	Frequency of Involvement	*Per Cent.*	*Frequency of Involvement*	*Per Cent.*	*Frequency of Involvement*	*Per Cent.*
Calcaneum	23	41.9	36	9.9	59	14.1
Astragalus	8	14.6	42	11.6	50	12.0
Metatarsal 1	12	21.9	33	9.1	45	10.8
Cuneiform 2	2	3.6	34	9.4	36	8.6
Scaphoid	0	0.0	34	9.4	34	8.1
Cuneiform 1	1	1.8	32	8.8	33	7.9
Cuboid	2	3.6	28	7.6	30	7.2
Cuneiform 3	0	0.0	30	8.3	30	7.2
Metatarsal 2	1	1.8	21	5.8	22	5.3
Metatarsal 4	1	1.8	20	5.5	21	5.0
Metatarsal 5	0	0.0	21	5.8	21	5.0
Metatarsal 3	0	0.0	18	4.9	18	4.3
Phalanx 1	2	3.6	12	3.3	14	3.4
Phalanx 2	2	3.6	2	0.6	4	0.9
Phalanx 5	1	1.8	0	0.0	1	0.2
Phalanx 3 and 4	0	0.0	0	0.0	0	0.0
Total	55 (53 cases)	100.0	363 (94 cases)	100.0	418 (147 cases)	100.0

TABLE III

DURATION OF DISEASE BEFORE FORMATION OF DRAINING SINUSES

Duration in Months	No. of Patients
0–1	31
1–4	46
4–7	25
7–10	6
10–13	11
13–16	0
19–22	2
22–25	0
25–28	1
28–31	1
31–34	0
34–37	0
37–40	2
40–72	2
Total	127

occurred before admission of the patient for treatment; and two in which tuberculous lesions of the toes healed spontaneously.

The diagnosis was confirmed by microscopic examination in 124 cases (84.3 per cent.). In the remaining twenty-three cases (15.6 per cent.), pathological specimens were not obtained, but the clinical diagnosis was made possible on the basis of: (1) a typical clinical course; (2) characteristic findings in the roentgenograms; and (3) evidence of tuberculous lesions in other parts of the body.

As shown in Table I, the disease was slightly more prevalent among the males than among the females, the ratio being 1.6 to 1.0. Also, the disease was more prevalent between the ages of ten and forty years. More than half of the cases among the males occurred within the third decade; among the females, approximately one-half of the cases occurred in the second decade of life.

In Table II, the cases are divided into two groups. The first group of fifty-three patients (36.0 per cent.) had isolated lesions of a single bone; and the second group of ninety-four patients (64.0 per cent.) had multiple lesions of two or more bones. In the first group, two patients showed lesions in both the right and left calcaneum, making a total of fifty-five instances of involvement of a single bone.

In a study of the relative frequency of involvement of the bones of the foot, it may be noted that the disease occurred more frequently in the calcaneum, astragalus, first metatarsal, scaphoid, and the first and second cuneiform bones. These bones are of first importance in transmitting weight from the tibia to the arches of the foot and, therefore, we believe

that the relative preponderance of lesions in these bones is a strong point in favor of the contention that trauma predisposes to the development of tuberculosis.

Out of a total of 147 patients, 127 (86.3 per cent.) showed draining sinuses. The sinuses developed usually during the first eight months after the onset of the first symptoms (Table III). Most of the patients came to the hospital for treatment soon after rupture of the abscess. In China, local needling and poultices are used commonly for all types of pain and inflammation, and therein probably lies the explanation for the relatively high incidence of sinus formation.

One or more associated lesions of active tuberculosis were found in 65 per cent. of the cases. The lungs were involved in 51 per cent.; the glands, in 17.8 per cent.; other bones, in 22.2 per cent.; and the intestines, the skin, and other tissues, in 11.1 per cent. These figures add emphasis to the fact that bone and joint tuberculosis is a secondary manifestation of a general disease in which the primary focus lies elsewhere. In this Clinic, from a careful study of the roentgenograms of the lungs of 100 patients with bone and joint tuberculosis (including various bones and joints), Meng and Chen found intrathoracic tuberculous lesions of varying degree in 78 per cent. of the cases. Under the term "intrathoracic lesions of varying degree", they included not only active parenchymatous lesions, but also all chronic and healed lesions of the lungs and tracheobronchial

TABLE IV

ANALYSIS OF RESULTS OF TREATMENT

Age (*Years*)	Type of Treatment Instituted	No. of Cases	Results							
			Good		Fair		Poor		?	
			No.	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*
1 to 16	Conservative treatment alone	4	1	25.0	3	75.0	0	0.0	0	0.0
	Curettage	21	5	23.7	6	28.6	9	42.9	1	4.8
	Local excision or amputation	21	17	80.9	1	4.8	3	14.3	0	0.0
	Total	46	23	50.0	10	21.7	12	26.1	1	2.2
16 to 60	Conservative treatment alone	1	1	100.0	0	0.0	0	0.0	0	0.0
	Curettage	22	3	13.6	7	31.8	11	50.0	1	4.6
	Local excision or amputation	60	50	83.3	1	1.7	9	15.0	0	0.0
	Total	83	54	65.1	8	9.6	20	24.1	1	1.2

lymph glands. In their group of 100 patients, active parenchymatous lesions were found in 47 per cent. of the cases.

In Table IV, the results of treatment are classified as follows: *good*, indicating local cure; *fair*, meaning apparent or almost complete local cure; *poor*, signifying no improvement, or progressive destruction of bone or dissemination of the tuberculous process; and *questionable*, indicating undetermined conclusions because of incomplete follow-up.

Only four of the patients from one to sixteen years of age and only one of the eighty-three patients aged sixteen or more years received conservative treatment alone. In the remainder of both groups, operative treatment was indicated because of the poor social or economic conditions and because of the advanced stage of the local disease.

FIG. 1

Illustration showing lines of excision of bones: *A* or *B* used for complete or partial removal of the os calcis; and *D* and *C*, for removal of the fifth metatarsal or the fourth and fifth metatarsals.

The operative treatment of both the young and the adult patients was essentially the same. In an attempt to find the best method of operative attack upon this disease, various procedures were used.

1. *Curettage:* Experience with the curetting operation was extremely discouraging, since most of the patients treated in this manner developed persistent draining sinuses and the disease continued to progress locally. This was found to occur not only in the isolated lesions, but also in the more extensive lesions of several bones. Consequently, after trial in forty-three cases, the method was abandoned.

2. *Excision:* Our attention was directed to the excision procedure by the results which were being obtained by Dr. Van Allen and his coworkers* in the treatment of tuberculosis of the rib. They excised the diseased ribs, the surrounding periosteum, and all involved soft tissues (including the sinus tracts, together with a margin of healthy tissue). The tissues were excised in much the same manner as would have been done in the case of a neoplasm, and, when the excision was complete, recurrence was not seen. The same principles of treatment were employed in twenty-

FIG. 2

Line *A* shows plane of excision for tuberculosis of the first metatarsal. Similarly, both the first and second metatarsals and toes may be removed.

* Unpublished work.

two cases of tuberculosis of the foot. In the cases with involvement of the toes alone, amputation was required and, in cases of involvement of the metatarsal or tarsal bones, complete excision of all of the area was necessary, even at the expense of removal of one-fourth or even one-half or more of the soft and bony structures of the foot.

In Figures 1, 2, 3, and 4 are sketched the various lines of excision as they concern the bones. Following the excision procedure in the patients with external sinuses, the wounds were closed in the usual manner. In the patients with draining sinuses and secondary infections, the raw surfaces of the wounds were covered with iodoform gauze and plaster-of-Paris casts were applied. After several days, openings were made in the casts, the iodoform packs were removed, and the surfaces of the granulation tissues were treated with Dakin's solution. As soon as the granulation tissue appeared healthy, Reverdin or Thiersch skin grafts were applied. If the wound continued to drain or to show evidence of further tuberculous infection, another excision operation was performed. In several cases, this procedure was repeated at intervals until a healthy surface was obtained for grafting. It is not possible to describe in detail the technique used in the individual cases, since every conceivable form of involvement of bone and soft tissue of the foot was encountered. Briefly, the excision method consisted of one or more operations until we felt satisfied that all of the tuberculous tissue was removed,—procedures which demanded slow and careful dissection of the soft tissues, with attempts to preserve the nerve supply. Technically, the excision operation is not particularly difficult. General anaesthesia is rarely necessary except in children. The danger of dissemination of tuberculosis is slight, and the wounds usually heal *per primum* or may be grafted with skin after two to five weeks. A patient with tuberculosis of the foot and without associated tuberculous lesions, once considered an invalid, may often again become a useful member of society in a few weeks' time. When associated lesions

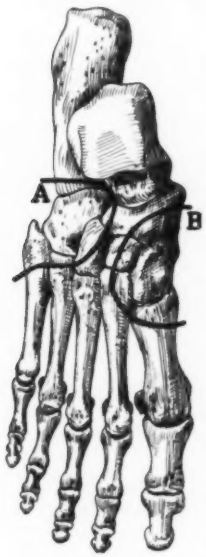


FIG. 3

B and *A* represent the lines of excision for isolated lesions of the internal cuneiform and cuboid bones. Portions of the surrounding normal bones are also excised, leaving a healthy surface for healing.

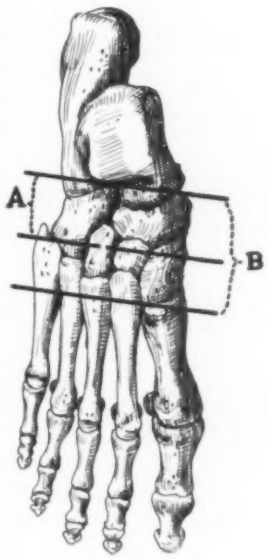


FIG. 4

Diagrammatic representation of the lines of excision used in tuberculosis of the anterior tarsal bones (after Ollier). The resection may include only Chopart's joint (*A*) or it may also include Lisfranc's joint (*B*).

FIG. 5

Photograph showing a cured case after excision of the cuboid, and the fourth and fifth metatarsal bones and toes. The diseased soft tissue also was excised.

FIG. 6

Photograph of a foot of a patient cured after resection of diseased soft tissue and bones, including the internal cuneiform, the first metatarsal bones, and the great toe.

are present, the patients are treated in the same way. We have observed repeatedly that the eradication of an advanced peripheral focus of tuberculosis allows more rapid healing of the primary lesion. The loss of part of the foot or even of the foot and part of the leg may terrify the laity, but such apprehension usually disappears when the patient sees other individuals walking about with well-fitting prostheses or artificial limbs.

INDICATIONS FOR AMPUTATION AND SURGICAL EXCISION

It is difficult to set down definite indications for the various types of surgical treatment, because of the great variation in the activity and extent of the disease. However, in general, our present plan of management may be summarized as follows:

1. Amputation through the leg is reserved for the most advanced cases in which the disease is wide-spread in the tarsal or metatarsal bones and surrounding soft tissues. Isolated lesions of the toes are usually treated by amputation. Occasionally, amputation is performed in cases with less extensive involvement (cases which might be cured by local excision of the tuberculous area). In such cases, this procedure is indicated chiefly because the economic condition of the patient is such that he is forced to return to a gainful occupation in the shortest possible period of time.

2. Excision is indicated in any case in which the disease is localized sufficiently, so that, even though the diseased area is removed entirely, a useful portion of the foot will remain. Thus astragalectomy, calcaneo-ectomy, or removal of the fifth metatarsal or fourth and fifth metatarsals and toes (with or without the cuboid) may be performed (Fig. 1). After complete removal of the calcaneum, the Achilles tendon should be fastened to the posterior-inferior surface of the astragalus (Miltner and

Wan). The first metatarsal or even the first and second metatarsals and toes may be removed and the remaining portion of the foot may be quite satisfactory for ordinary use (Fig. 2). For single localized lesions of the smaller tarsal bones, the excision operation is particularly applicable (Fig. 3). The Ollier anterior tarsectomy (Fig. 4) is another form of excision operation which may effect a cure in extensive lesions of that area.

CONCLUSIONS

In advanced cases of tuberculous lesions of the bones and soft tissues of the foot, amputation through the leg is advised.

Treatment by careful surgical excision has proved to be an excellent method of management for advanced local lesions, especially those in adult patients. By this means, it is often possible to eradicate entirely the local disease and to save a useful portion of the foot.

BIBLIOGRAPHY

Brackett, E. G.: Tuberculosis in China. J. Bone and Joint Surg., IV, 823, Oct. 1922. Treatment of Bone and Joint Tuberculosis. J. Bone and Joint Surg., VI, 832, Oct. 1924.

Calvé, Jacques: Treatment of Tuberculosis of the Ankle in the Adult. J. Bone and Joint Surg., IV, 33, Jan. 1922.

Chiari, D. O. M.: Zur Operation der Fusswurzelcaries nach Kirschner. Deutsche Ztschr. f. Chir., CLX, 277, 1920.

Cotton, F. J.: Tuberculosis of the Tarsus. Old Case. Surg. Clin. North America, I, 906, 1921.

Fitzsimmons, H. J.: Tuberculosis of Ankle Joint and Tarsus. Boston Med. and Surg. J., CLXXXVII, 838, 1922.

Gaenslen, F. J., and Schneider, C. C.: Treatment of Tuberculosis of the Ankle in the Adult. J. Am. Med. Assn., LXXVII, 1168, 1921.

Geist, E. S.: Anterior Tarsectomy (Ollier) in Tuberculosis of the Anterior Tarsus. J. Bone and Joint Surg., VIII, 410, Apr. 1926.

Hibbs, R. A.: The Treatment of Tuberculosis of the Joints of the Lower Extremities by Operative Fusion. J. Bone and Joint Surg., XII, 749, Oct. 1930.

Hsieh, C. K., Miltner, L. J., and Chang, C. P.: Tuberculosis of the Shaft of the Large Long Bones of the Extremities. J. Bone and Joint Surg., XVI, 545, July 1934. Tuberculosis of the Shaft of the Large Long Bones of the Extremities. Chinese Med. J., XLVIII, 199, 1934.

Humphries, R. E., and Durham, H. A.: End-Results of the Treatment of Tuberculosis of the Spine, Hip, Knee and Ankle Joints. From the Records of the New York Orthopaedic Dispensary and Hospital. J. Am. Med. Assn., LXVIII, 282, 1917.

Jones, Sir Robert: Treatment of Tuberculosis of the Ankle in the Adult. Discussion. J. Am. Med. Assn., LXXVII, 1171, 1921.

Lo Grasso, Horace: The Non-Operative Treatment of Tuberculous Joints of the Lower Extremities. J. Bone and Joint Surg., XII, 755, Oct. 1930.

McGavin, Lawrie: The Treatment of Tuberculous Disease of the Tarsus. Clin. J., XXIII, 300, 1904.

Meng, C. M., and Chen, H. I.: The Association of Intrathoracic Lesions with Bone and Joint Tuberculosis. A Study of 106 Cases. J. Bone and Joint Surg., XVII, 552, July 1935.

Miltner, L. J., and Wan, F. E.: Giant-Cell Tumor of the Os Calcis. Report of a Case Treated by Resection and Tendon Transplantation. J. Bone and Joint Surg., XIV, 406, July 1932.

MURPHY, J. K.: The Radical Treatment of Tuberculous Disease of the Tarsus and Ankle-Joint. British Med. J., II, 1145, 1910.

OLLIER: De la tarsectomie antérieure totale ou antéro-tarsectomie. Rev. d'Orthop., II, 174, 1891.

ROLLIER, A.: The Conservative Treatment in Surgical Tuberculosis of the Lower Extremity. J. Bone and Joint Surg., XII, 733, Oct. 1930.

SEVER, J. W.: Tuberculosis of the Ankle-Joint and Tarsus. J. Am. Med. Assn., LV, 2128, 1910.

STEARNS, THORNTON: Treatment of Tuberculosis of the Knee Joint in China. J. Bone and Joint Surg., V, 437, July 1923.

ROENTGENOGRAPHIC FEATURES OF RHEUMATOID ARTHRITIS *

BY ALBERT B. FERGUSON, M.D., NEW YORK, N. Y.
Director of Roentgenology, New York Orthopaedic Dispensary and Hospital

The term "rheumatoid arthritis" as used in this article is that form of multiple arthritis which typically begins before the age of thirty-five and tends to loss of cartilage and bone at the joints, deformity and eventual ankylosis, emaciation of the patient, elevation of the sedimentation rate of the blood, and positive response to the streptococcus agglutination test.

The roentgenographic features which characterize this disease and which are helpful in diagnosis are the subject of this discussion.

ROENTGENOGRAPHIC EXAMINATION

Roentgenograms for the detection of rheumatoid arthritis should depict the soft-tissue shadows as clearly as the bone shadows. In rheumatoid arthritis, particularly in the early stages, there are changes in the soft tissues at the joints and changes in the relative density of bone and soft tissues which are important and which can be detected only if the soft tissues are clearly pictured.

Examination should not be confined to a single joint. Rheumatoid arthritis is a systemic disease. Its diffuse manifestations may not be appreciated if examination is not extensive. Also, the joint of which the patient complains may not be the joint which is most characteristic of the disease roentgenographically. For these reasons, it is recommended that the hands, feet, knees, and lumbar spine be examined in every case in which doubt as to the diagnosis exists, regardless of the presence or absence of clinical evidence of disease in the regions mentioned.

EARLY MANIFESTATIONS

Rheumatoid arthritis is generally accompanied by a decrease in the calcareous density of the bones, which is most readily noted in the hands and feet. The bones are not as dense as they should be at the age of the patient; they appear too old for the patient. The whole of each bone is affected, although the change is not as readily noticeable in the cortical as in the cancellous areas. This systemic decrease in bone density may be the earliest roentgenographic manifestation of the disease. The few patients who do not reveal this decalcification are usually those in whom the disease developed late in life or who previously had had gonorrhoea.

An early feature in rheumatoid arthritis is the development of a soft-tissue mass at the joint, which we shall call an effusion, although it may in fact represent effusion, granulations, or synovial thickening. The pres-

* Read before The American Society for the Study of Arthritis, New York City, December 13, 1935.

ence of such effusion is evidenced by displacement or replacement of fat pads at a joint by a more dense soft-tissue mass, or by distention of the capsule at a joint, or by displacement of adjacent muscle outlines away from a joint. At the joints of the phalanges such an effusion may be highly characteristic of rheumatoid arthritis in that the effusion is definitely fusiform in shape, with the fusiform shadow symmetrically centered on the joint. Such a characteristic shadow may be demonstrable in the hands even when the joint complained of is elsewhere.

LATER MANIFESTATIONS

As rheumatoid arthritis advances, some loss of bone substance may appear. This has a certain specific character which we may describe as small punched-out areas of atrophic loss of substance at the junction of bone and cartilage. By the term "punched-out" we mean that the bone is lacking as if removed with a punch—the area of bone loss is rounded and there is no reaction in the adjacent bone; that is to say, there is no condensation in the bone texture and no haziness or smokiness due to soft-tissue reactions within the bone. When the lesion subsides and repair occurs, a thin line of dense bone may form on the surface of the area of loss of substance, but this is not to be confused with the wide condensation area or other changes indicative of reaction about the lesion which distinguish other forms of bone destruction from punched-out areas of atrophic loss of substance.

Other manifestations of the disease which may appear are thinning of the cartilaginous joint space, ankylosis, and, in repair, calcareous lipping at the margins of the joint. These changes, however, are not often useful in differential diagnosis.

DIFFERENTIAL DIAGNOSIS

Osteo-Arthritis

Osteo-arthritis does not produce lack of density of the bones beyond what is consistent with the age of the patient. It does not tend to produce effusion, particularly fusiform effusion, at the small joints. Osteo-arthritis produces calcareous lipping at the joint margins, which may be simulated by reparative calcifications in rheumatoid arthritis, but osteo-arthritis does not produce the punched-out areas of loss of substance which are usually present in rheumatoid arthritis when reparative lipping is present, and the underlying bony joint surfaces are comparatively normal in most cases of osteo-arthritis but frequently irregular in rheumatoid arthritis. When there is doubt as to the nature of the lesion, extensive examination should settle the question; usually some joint somewhere can be found that is typical of one condition or the other. Not infrequently both conditions are present in the one patient.

Gout

Punched-out areas of atrophic loss of substance occur in gout as in rheumatoid arthritis, but gout does not cause systemic loss of bone

density beyond that consistent with the age of the patient. In gout, the effusion does not tend to be fusiform and centered on the joint, but is more spherical or oval and is eccentrically placed; often it is centered on an area of loss of substance instead of on the joint. In acute gout, there may be marked diffuse swelling about the joint, but such swelling beyond the confines of the joint capsule is never a prominent feature of rheumatoid arthritis.

Atrophic Arthritis of the Toes Following Gonorrhoea

This condition is possibly a special type of rheumatoid arthritis. It is not a gonococcic infection of the joints in the usual sense. The metatarsophalangeal joints are involved. Characteristically, the involvement is multiple. The metatarsal heads reveal atrophic loss of substance which may be very marked, but there is no visible effusion as would be present in the ordinary rheumatoid arthritis. Some bone has been lost and that constitutes the whole of the local lesion. The bones are usually as dense as they should be for the age of the patient. The patients with this condition usually have spurs of post-gonorrhoeal type on the plantar angle of the heel,—that is, the spurs are very uneven in outline and density and do not present the clear osseous structure which is usually present in spurs of other types, such as those occurring in osteo-arthritis.

The Specific Infections

Rheumatoid arthritis may cause decreased density of the bones with the right and left sides similarly affected, but it does not cause unilateral variations in density. Hence, if the bone density is different on the two sides, the difference is not due to rheumatoid arthritis. This fact alone will serve to distinguish most instances of specific infectious lesions, such as tuberculosis, pyogenic infection, gonococcic infection, and some syphilitic lesions.

Rheumatoid arthritis does not cause exuberant calcareous productive reaction or dense subperiosteal calcification, such as often occurs in pyogenic and syphilitic lesions.

Destruction that occurs in specific infectious lesions differs from the punched-out areas of loss of substance of rheumatoid arthritis in that the involved areas tend to be larger, the adjacent bone varies from normal density, and the margins are irregular and appear eroded instead of punched-out.

Lesions in the Spine

In the spine, the characteristics of rheumatoid arthritis which we have emphasized are not often seen, as the mass of tissue is so great that slight changes are obscured. Rheumatoid arthritis in the spine (Marie-Strümpell arthritis) tends to slurring or lack of clearness of the articular facets, irregular depressions in the articular surfaces of the facets, and ankylosis through the ligamentous structures without loss of the intervertebral disc.

When the spine is affected, the extremities should also be examined if the diagnosis is questionable.

Osteo-arthritis in the spine develops calcareous lipping or osteophytic formation at the margins of the joints, particularly at the margins of the bodies. It does not tend to ankylosis except when the osteophytes are excessively exuberant.

Neither rheumatoid arthritis nor osteo-arthritis presents destructive lesions of the vertebral bodies, and thinning of the vertebral discs in these diseases is accompanied by definite osteophytic formation or by ankylosis. They do not produce abscesses.

By these means the specific infectious lesions in the spine are readily differentiated.

SUMMARY

Roentgenograms for the study of rheumatoid arthritis should display the soft-tissue shadows as clearly as the bone shadows.

The hands, feet, knees, and lumbar spine should be included in the examination.

The roentgenographic features most useful in the diagnosis of rheumatoid arthritis are systemic decalcification of the bones, fusiform effusion symmetrically centered on the joints (particularly the joints of the phalanges), and punched-out areas of atrophic loss of bone substance at the junction of cartilage and bone.

FRACTURE OF THE LATERAL CONDYLE OF THE HUMERUS IN CHILDHOOD *

BY PHILIP D. WILSON, M.D., NEW YORK, N. Y.

Judging by the lamentable late results of fracture of the lateral condyle of the humerus in children, which are encountered each year in our orthopaedic clinics, one may say without charge of unfairness that the medical profession has failed as yet to grasp the importance of this pathological lesion. Yet there is little excuse for this lack of understanding, because the injury is one of the most characteristic of all the fractures in the region of the elbow, and much has been written in regard to it. The most probable explanation is that many physicians do not comprehend the true nature of the pathology and depend upon the remarkable healing and restorative powers possessed by children to accomplish more than is possible under the circumstances. Also, this is one of the less common fractures of the elbow and physicians may not encounter it frequently enough to be able to differentiate it and put it in a class apart from other injuries of the lower end of the humerus. Whether these reasons are correct or not, it is true that this fracture seems to escape recognition and to receive less satisfactory treatment than almost any other fracture of the elbow.

FREQUENCY

Massart and Cabouat [4] estimated that fractures of the lateral condyle constituted one-third of all the fractures of the lower end of the humerus, but this figure is entirely too high in the author's opinion. In a previous analysis of 439 fractures and dislocations of the elbow [8], the writer found eleven examples of this fracture, or 2.5 per cent. Fracture of the lateral condyle represented nearly 6 per cent. of the 189 fractures of the lower end of the humerus, but only about 0.2 per cent. of the total number of 4,536 fractures and dislocations treated.

AGE

The fracture occurs within a fairly narrow age range, and this is necessarily so, because of the epiphyseal ossification of the lower end of the humerus, which plays an important rôle in determining the nature of this fracture. Of the patients seen by the author, the youngest at the time of the injury was three years old and the oldest was thirteen years of age. The surgeon frequently encounters the lesion in adults, but, in such cases, he is dealing with the late results of the injury and, upon inquiry, will find that the fracture originated in early childhood.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 15, 1936.

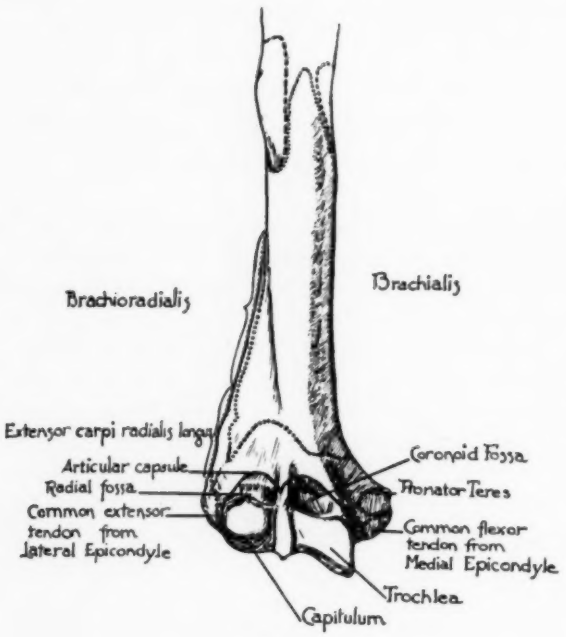


FIG. 1

Drawing of the lower end of the humerus, showing the muscle attachments.

PATHOLOGY

The injury consists of a fracture starting at the lateral side of the lower end of the humerus, at a point from about one-quarter of an inch to one-half an inch above the epiphyseal line of the capitellum, and extending obliquely inward and downward to the region of the trochlea, where it breaks through the articular cartilage into the elbow joint, thus separating a triangular fragment with a diameter of from one inch to one and one-half inches and consisting of the capitellar epiphysis and a fragment of the metaphysis. Through a part of its course, the line of fracture may correspond with the epiphyseal line, but invariably a thin plaque of bone is detached from the metaphysis, chiefly from the lateral border and the posterior surface.

The displacement is of variable amount; its complete form consists of a rotary dislocation outward and backward of the condylar fragment. The arc of rotation of the horizontal axis of the fragment may be 90 degrees or more. The articular surface thus faces medially and upward instead of downward. This displacement is due to the contraction of the long extensor muscles of the wrist and fingers, which take their origin by means of a common tendon from the lateral condyle of the humerus. The brachioradialis originates from the humerus at a higher level and, therefore, is not involved. At operation, the author has found these long extensor muscles stripped away from the lateral surface of the humerus, but retaining their attachment to the condylar fragment. There is generally a transverse tear in the muscular aponeurosis, from one-half an inch to one inch in width, directly overlying the condyle. The lateral ligament of the elbow retains its attachment to the condylar fragment and provides a hinge upon which the fragment rotates.

The degree of rotary displacement is probably governed by the width of the tear in the muscular aponeurosis, since the ability of the muscles to pull the lateral border of the condylar fragment downward

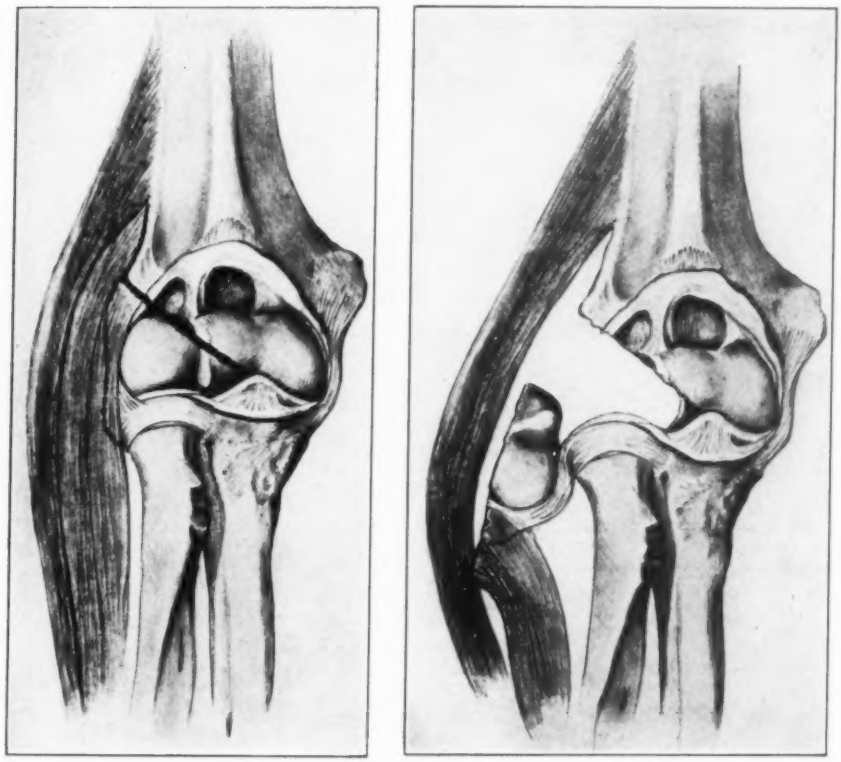


FIG. 2-A FIG. 2-B

Schematic drawing illustrating fracture and rotary displacement of the lateral condyle of the humerus.

Fig. 2-A: Showing line of fracture in relation to muscular and ligamentous attachments.

Fig. 2-B: Showing rotary displacement, due to pull through the common tendon of the extensor muscles and limiting action of the lateral ligament.

depends upon the extent to which they are freed from the adjacent muscles. In every case, the intact lateral ligament limits the displacement. When the displacement is of the incomplete type, it is probable that the overlying muscular aponeurosis has remained intact. In such cases, the condylar fragment is displaced laterally and somewhat posteriorly, but is not rotated upon its horizontal axis. Another element commonly present in the displacement is axial torsion, as a result of which the lateral margin of the fragment is carried posteriorly and the mesial border is brought forward.

The essential point to be emphasized in a case of rotary displacement is that the fractured surface of the condylar fragment is carried away from any contact with its opposing surface on the lower end of the humeral shaft and that in its place is substituted the smooth articular cartilage of the inferior surface of the fragment. Under these circumstances, healing by bony union is impossible and pseudarthrosis invariably results. As long ago as 1825, Sir Astley Cooper[3] reported that he had studied two

FIG. 3

Ununited fracture of the lateral condyle of the humerus in a child of fifteen years, eight years after injury.

gross specimens of this type of fracture which showed only ligamentous union. He stated: "If the whole extent of the fracture be within the ligament it does not, so far as I have seen, unite by bone whatever may be the means employed." He evidently assumed that there was interference with the nutrition of the bony fragment. Massart and Cabouat[4] fell into the same error and assumed that interruption of the blood supply to the condylar fragment accounted for the frequency of non-union. However, from a study of old cases with non-union, it is obvious that this is incorrect, because it will invariably be seen that the condylar fragment has increased in size and that the epiphysis has continued to function after the fracture. Furthermore, at operation it can be demonstrated that the condylar fragment retains sufficient ligamentous and muscular attachments to permit blood to reach it through the epiphyseal and metaphyseal vessels. Additional evidence, showing that the loose fragment receives ample nutrition, is furnished by the fact that when the latter is replaced, so that the fractured surfaces are brought into contact, healing by bony union proceeds promptly. From these facts, we may conclude that failure of bony union is always the result of wide separation of the fractured surfaces and that, if the displacement is corrected, bony healing may be expected in all cases.

MECHANISM OF INJURY

The cause of the injury is usually a fall, but it is generally impossible to ascertain from the patient's story whether the force was transmitted through the outstretched hand or received directly upon the elbow. In discussing this point, Stimson[6] stated: "I have found it easy to produce the fracture by adduction of the extended forearm in bodies of the young, or by a blow upon the palm with the elbow flexed at a right angle." From a consideration of the nature of the lesion, one would conclude that indirect trauma played the major rôle and that the mechanism was generally adduction of the forearm upon the humerus, with the elbow incompletely extended, thus causing strain upon the external lateral ligament and evulsion of the condyle. This would account for the tear in the overlying muscular aponeurosis and the rotary dislocation of the fragment outward and backward as a result of muscle pull. It is probable that in the cases with incomplete displacement and absence of rotary

deformity the fractures are produced by a force transmitted directly upward through the radius to the capitellum from a fall upon the outstretched hand.

EPIPHYSEAL DEVELOPMENT

Cohn[2], in describing the epiphyseal development and ossification of the lower end of the humerus, stated that the capitellar epiphysis is the first to appear and may be recognized as early as from seventeen months to two years. The epiphysis of the internal epicondyle appears at about seven years, but always remains separate from the lower humeral epiphysis and unites with the shaft directly. There may be two separate centers for the trochlea, or only one, and these usually make their appearance at about the eighth to the tenth year. A separate center for the external epicondyle is the exception rather than the rule. By the age of ten years, the capitellar epiphysis has broadened considerably and occupies approximately half of the base of the humeral shaft, from the middle outward. In the lateral view, the epiphysis lies anterior to the axis of the shaft, giving somewhat the appearance of a short-ended hockey stick. The capitellar epiphysis fuses with the trochlear epiphysis from the age of eleven to thirteen years, and shortly after-

FIG. 4

Drawing from illustration of Camp and Cilley[1] showing ossification of the lower end of the humerus. According to Cohn[2], the capitellar epiphysis appears at seventeen months and fuses with the trochlear epiphysis at from eleven to thirteen years; the combined epiphysis unites with the shaft at from thirteen to fourteen years.

FIG. 5-A FIG. 5-B

Ununited fracture of the lateral condyle of the humerus. Delayed ulnar-nerve palsy developed at age of forty-eight years, more than forty years following the injury.

ward the entire epiphysis unites with the shaft, generally at about the age of thirteen to fourteen years.

True epiphyseal displacement of the lower end of the humerus almost never occurs, and there was no example of such an injury in over 500 cases of fracture or dislocation of the elbow that were studied by the author. The reason for this is clear. The various bony centers do not become fused together, so that separation as a single unit becomes possible, until the age of thirteen, and at this time union of the epiphysis with the shaft is so far advanced that fracture is more easily produced than epiphyseal displacement.

Fracture of the lateral condyle and capitellar epiphysis takes the place of epiphyseal separation of the lower end of the humerus, and is its equivalent. It occurs from the age of three to thirteen years. During this period, the capitellar epiphysis is the only existing osseous center, with the exception of the internal epicondyle, which is much more an apophysis than an epiphysis. The reasons why the fracture of the lateral condyle is rarely entirely epiphyseal are that the capitellar epiphysis is entirely intracapsular and that the ligaments of the elbow through which strain may be exerted are attached to the metaphysis. When force is transmitted upward through the radius to the capitellum, the elbow is always in incomplete extension; in this position, as a result of the forward projection of the lower articular end of the humerus, the epiphysis is buttressed posteriorly by the metaphysis, which must be fractured if the capitellum is displaced. The author has seen pure epiphyseal fracture of the capitellum as a complication of dislocation of the elbow in the young, but even then such an injury is exceedingly rare.

The upper age limit for fracture of the lateral condyle in children is about thirteen years, at which time the capitellar epiphysis fuses with the trochlear epiphyses, to be followed shortly afterward by union of the entire epiphysis with the shaft.

LATE COMPLICATIONS

The frequency of late complications of ununited fracture of the lateral condyle of the humerus in children is notorious. Due to a separation of the important capitellar growth center, the lower end of the humerus develops irregularly. The mesial half grows normally, due to the undamaged state of the trochlear epiphyses, while the lateral portion is deprived of its normal growth increment. Since many of the fractures occur at as early a period as from three to five years of age, it is apparent that a very considerable irregularity of growth can result before the trochlear epiphyses become fused with the shaft. The plane of the lower articular surface of the humerus changes gradually from horizontal to oblique, sloping upward and outward, and there is an increasing degree of cubitus valgus deformity. This may cause a very conspicuous alteration in the alignment of the elbow.

In spite of the ununited condylar fragment, the function of the elbow

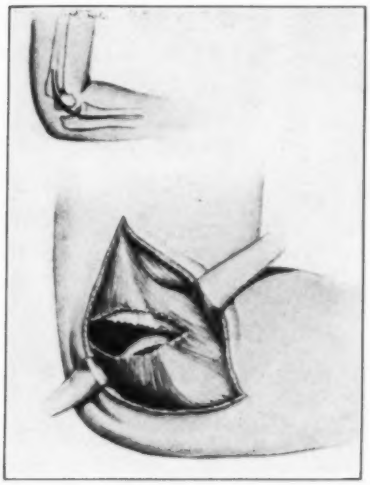


FIG. 6-A

Appearance of tear in muscular aponeurosis and displacement of fragment seen at operation. The fractured surface of the fragment faces outward.

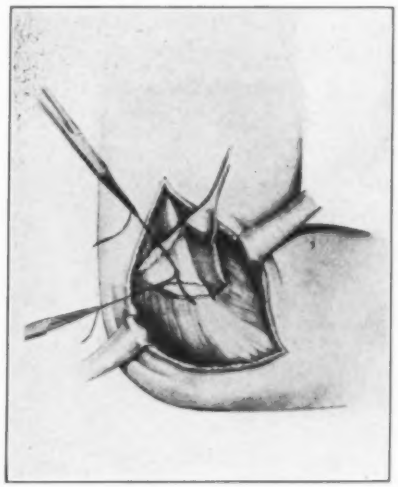


FIG. 6-B

Method of fixing fragment by silk suture passed through ligamentous attachments to lateral condyle and drill hole in distal end of fragment of shaft.

joint continues surprisingly good. The patients have but little pain, and when they are brought to the hospital it is because of the deformity of the elbow rather than because of any disability. Upon examination, a certain amount of crepitation can be detected in the elbow, and sometimes movement of the loose fragment can be demonstrated. Generally there is nearly a full range of flexion and extension, and pronation and supination are complete. The patients may complain of weakness of the arm, but the writer has seen some who were capable of performing heavy laborious work without ill effects.

Delayed ulnar-nerve palsy is a very common late result of ununited fracture of the lateral condyle in children. Many instances of this condition have been reported, and, because of its frequency, this late complication has attracted more attention to fracture of the lateral condyle than the more immediate results. The symptoms of ulnar-nerve palsy develop gradually after an interval ranging from fifteen to fifty-five years. The patient notices a sensation of numbness in the ulnar-nerve distribution to the fingers and weakness and awkwardness in the finer movements of the hand. Examination reveals wasting of the interosseous muscles, weakness of the movements involving the muscles supplied by the ulnar nerve, and diminished sensation in the ulnar area of the fingers. The paralysis is generally incomplete. There is a marked cubitus-valgus deformity of the elbow and a history of injury in early childhood, and the roentgenographic examination discloses an old ununited fracture of the lateral condyle. Frequently, thickening and sensitiveness of the ulnar nerve can be demonstrated in the groove behind the internal epicondyle. The ulnar palsy is due to a localized pressure neuritis caused by the stretching

FIG. 7-A

Case F. V., aged six years. Fracture of lateral condyle with incomplete displacement. Before operation.

FIG. 7-B

Case F. V. Four days after open reduction and suture.

of the nerve, due to the increasing cubitus valgus deformity and movement of the elbow. The condition can be completely relieved by operative transposition of the ulnar nerve to the front of the elbow.

DIAGNOSIS

The diagnosis of fracture of the lateral condyle can generally be made at the time of injury by careful clinical examination. The swelling and ecchymosis are confined chiefly to the lateral portion of the elbow joint, and the tenderness is also localized in this region. Supracondylar fracture can be ruled out by the absence of the characteristic deformity, and frac-

ture of the upper end of the radius can be eliminated by the free mobility in pronation and supination. There is, however, no necessity for any manipulation that may cause pain, since the chief reliance must be placed

FIG. 8-A

Case J. V., aged six years. Fracture with complete rotary displacement and torsion. Before operation. (Case of Dr. E. A. Van Derwerker.)

FIG. 8-B

Case J. V. Three weeks following operative reduction and suture.

FIG. 9-A

Case H. V., aged five and one-half years. Fracture with complete rotary displacement. Before operation. (Case of Dr. Fenwick Beekman.)

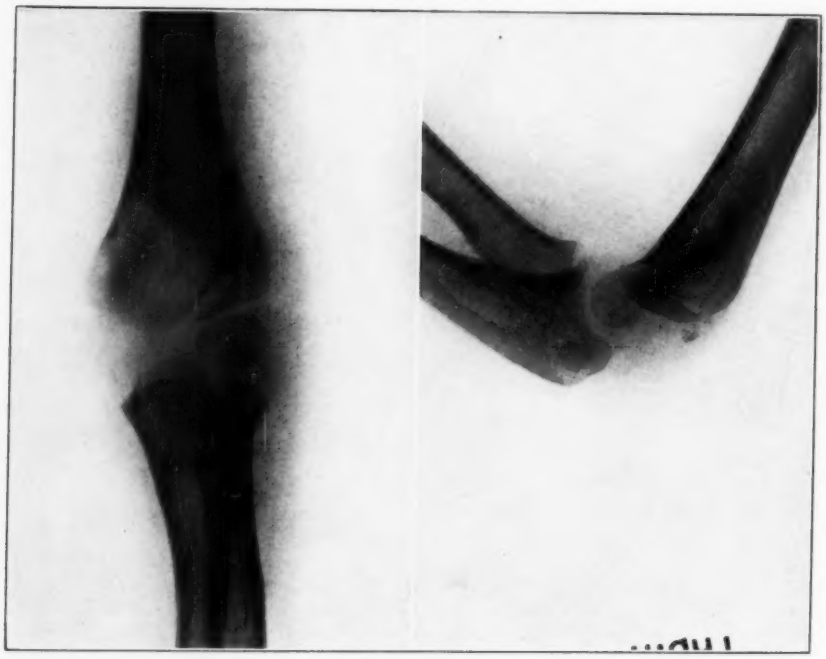


FIG. 9-B

Case H. V. Following operative reduction and suture of torn muscles.

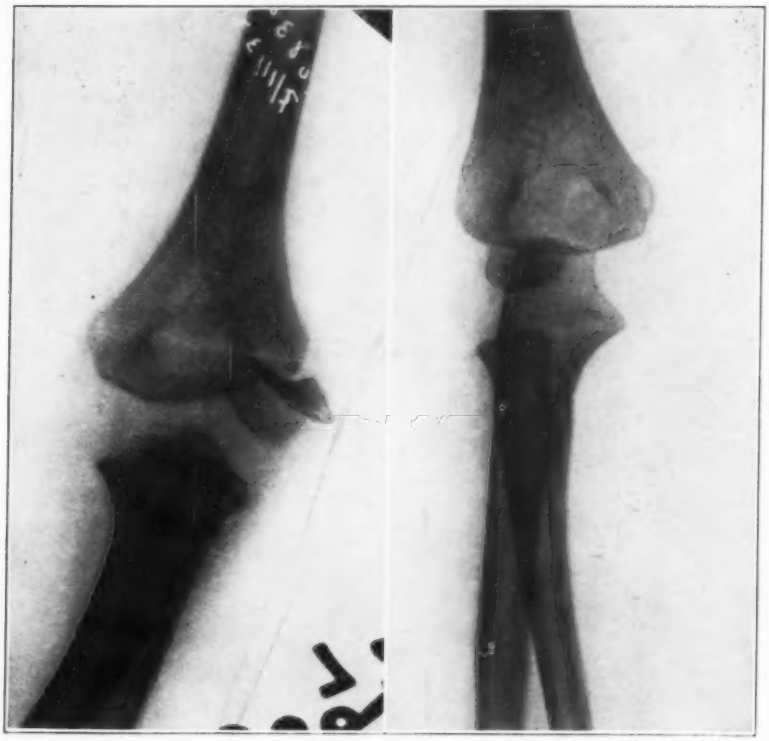


FIG. 10-A

Case A. H., aged five years. Fracture with incomplete type of displacement. Before operation.

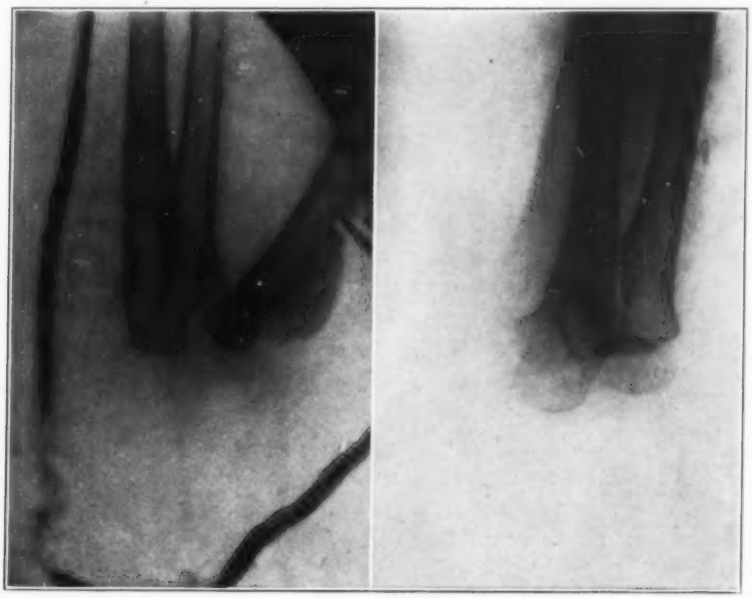


FIG. 10-B

Case A. H. Three days after open reduction and suture. Complete reposition.

FIG. 11-A

Case L. Z., aged seven years. Fracture with incomplete displacement. Before operation.

FIG. 11-B

Case L. Z. Eighteen months after open reduction. Normal function and alignment.

upon the roentgenographic examination, which is always necessary before making a diagnosis.

There should be no difficulty in recognizing the fracture from inspection of the roentgenograms. The rotated displaced condylar fragment can be seen lying in the soft parts at some distance from its normal position. The chief enlightenment as to the condition is obtained from the roentgenogram made in the anteroposterior plane; the lateral view often fails to shed any additional light because of the superimposed shadows.

TREATMENT

In the cases with little or no displacement, simple splinting methods which fix the elbow in the position of acute flexion are sufficient. When displacement is present, however, operative reduction is almost invariably necessary and should be performed promptly. A rare case has been reported, in which a rotated fragment was replaced by closed manipulation, but this method fails so uniformly that the author considers it folly even to attempt it. When operation is performed within the first two or three days, replacement is accomplished easily and with a minimum of trauma. The fracture is exposed through a lateral incision. A forceps is applied to the muscles and ligaments attached to the lateral condyle and this is

pulled upward while, at the same time, the fragment is pressed forward into normal position with the fingers.

Surgical opinion differs as to the necessity of internal fixation of the fragment. Stone[7] and others have reported that, when replacement was obtained, they were able to hold the fragment in position by simply placing the elbow in the position of acute flexion. Other surgeons[5] have employed steel nails or pins. The author would not hesitate to use a pin if it were necessary, as is frequently the case when the operation is performed after a considerable interval. The disadvantage of a pin is that it transfixes the epiphyseal cartilage and is liable to cause disturbance of growth. For this reason, the writer much prefers to rely upon simple suture of the fragment with silk. It is possible to fix the suture securely to the condylar fragment by passing it through the ligamentous and muscular attachments. The distal end of the shaft is generally stripped bare of soft tissues, however; for this reason, a drill hole must be made in the external supracondylar ridge directly above the fracture line. When the other end of the suture is passed through this hole and tied, the fragment is securely fixed in position, and the surgeon is protected against the possibility of later displacement, which is always an unfortunate complication after open reduction. Following closure of the wound, a posterior plaster splint is applied with the elbow fixed in a position of moderate flexion.

Fixation of the elbow is maintained for a period of three to four weeks, depending upon the age of the child. At the end of this time, the splint is removed and the arm is protected by a sling for a period of one week or longer. Motion is permitted and encouraged after the removal of the splint, and, as a rule, active use can be allowed at the end of four to five weeks. Function is regained quickly, and normal alignment and function can be expected as the final result. The author has seen only one instance of interference with growth of the capitellar epiphysis in cases where union has been obtained with good position.

It needs to be emphasized that operative replacement of the condylar fragment becomes increasingly difficult with the lapse of time. The muscles causing the displacement become contracted and fixed in their new position. Granulation tissue grows in and fills the gap in the torn muscles. The normal anatomy becomes obscured, and, after two to three weeks, the matter of securing reduction, even by open operation, is a real problem. In such cases, it may be necessary to free some of the ligamentous and muscular attachments to the condylar fragment, but this involves sacrifice of the blood supply and may vitiate the result. In the author's opinion, excision of the condylar fragment, which is the easy alternative, ought never to be done except in the very late cases. The writer knows of a case (Fig. 13) in which operation was performed by Dr. W. A. Rogers as late as two years after the injury, and it was possible to freshen the fractured surfaces, to insert a bone graft between the end of the shaft and the condylar fragment, and, by solid fixation with a

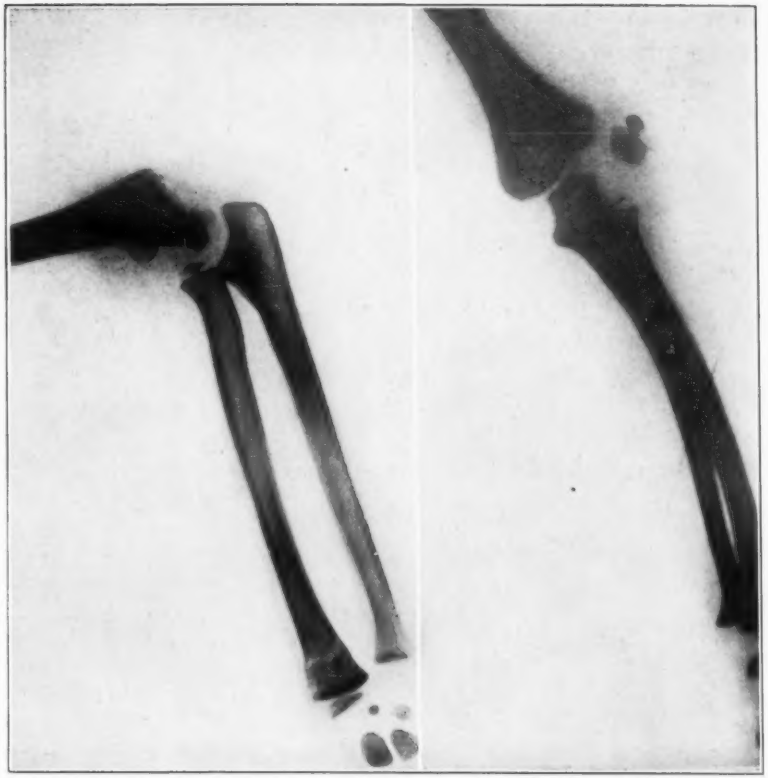


FIG. 12-A

Case D. F., aged three years. Fracture with complete rotary displacement. Before operation.

FIG. 12-B

Case D. F. One year after open reduction and suture.

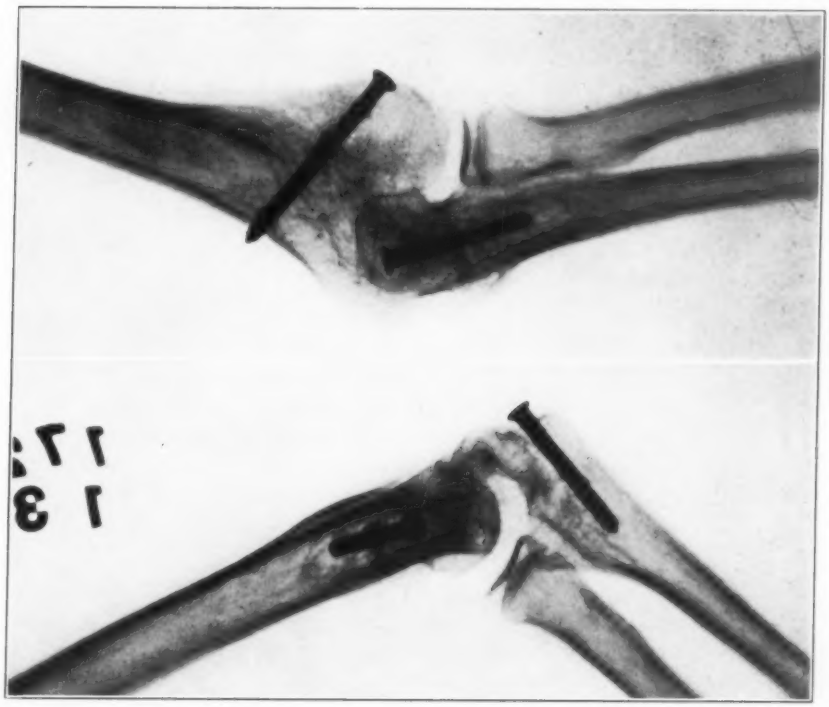


FIG. 13-B

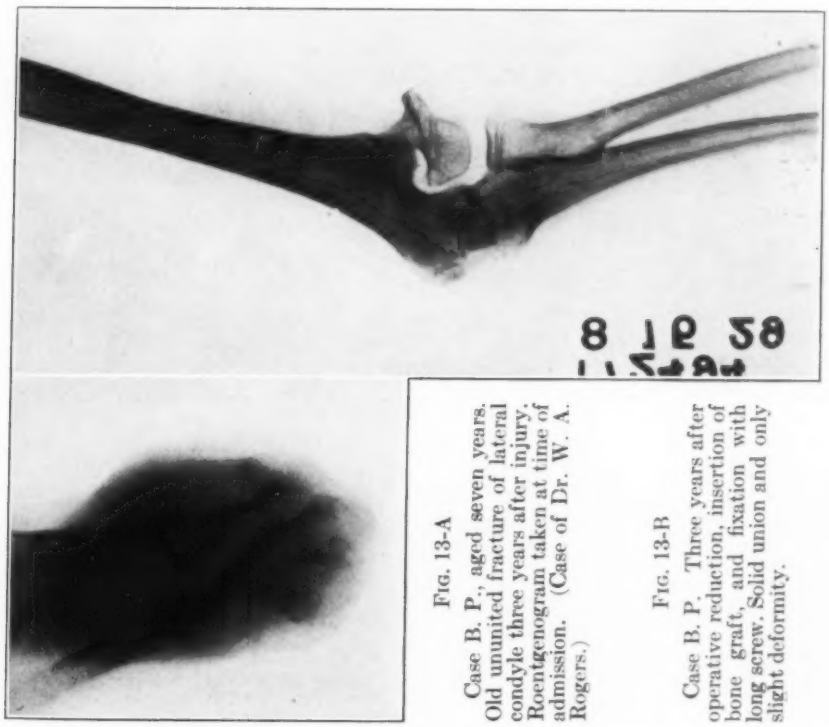


FIG. 13-A

FIG. 13-A

Case B. P., aged seven years. Old ununited fracture of lateral condyle three years after injury. Roentgenogram taken at time of admission. (Case of Dr. W. A. Rogers.)

FIG. 13-B

Case B. P. Three years after operative reduction, insertion of bone graft, and fixation with long screw. Solid union and only slight deformity.

long screw, to obtain union. It seems to the author that a procedure of this type is preferable to excision, and that the subsequent deformity of the elbow, due to growth disturbance, will be much less than when the fragment is removed.

Correction of cubitus valgus deformity, resulting from failure of union of a fracture of the lateral condyle of the humerus in childhood, is frequently necessary. This requires a supracondylar osteotomy and excision of a bony wedge with a sufficient base at the medial border of the humerus to permit the plane of the lower articular end of the humerus to be brought into normal relation with the axis of the shaft. The writer has found it difficult to retain the fragments in alignment following such an operation and has adopted the procedure of fixing them with a steel bone plate in order to avoid postoperative displacement. Delayed ulnar-nerve palsy can be prevented by correction of the cubitus valgus deformity at an early age, and the possibility of this later complication is an additional reason for advising operation before nerve symptoms have developed.

CONCLUSIONS

Fracture of the lateral condyle of the humerus in children is a serious injury and, unless treated properly, results in failure of union, weakened function, marked cubitus valgus deformity, and delayed ulnar-nerve palsy. The condition of pseudarthrosis is due to the extreme rotary displacement of the condylar fragment and, in order to overcome this, operative reduction is necessary. Good approximation is followed by bony union, recovery of normal function, and absence of any later complications. It is important for physicians to learn to recognize this fracture in order that it may receive early surgical treatment.

BIBLIOGRAPHY

Articles Quoted

1. Camp, J. D., and Cilley, E. I. L.: Diagrammatic Chart Showing Time of Appearance of the Various Centers of Ossification and Period of Union. Am. J. Roentgenol., XXVI, 905, 1931.
2. Cohn, Isidore: Normal Bones and Joints Roentgenologically Considered. New York, Paul B. Hoeber, Inc., 1924.
3. Cooper, Sir Astley P.: A Treatise on Dislocations, and on Fractures of the Joints. First American Edition from the Third London Edition. Boston, Wells and Lilly, 1825.
4. Massart et Cabouat: Les fractures du condyle externe chez l'enfant. Étude clinique et radiographique de ces fractures et de leurs résultats éloignés. Rev. d'Orthop., XV, 475, 1928.
5. Murphy, J. B.: Disjunction of Lower Epiphysis of Humerus, Open Reduction, Fixation by Nail. Surg. Clin. Philadelphia and London, V, 277, 1916.
6. Stimson, L. A.: A Practical Treatise on Fractures and Dislocations. Ed. 7. Philadelphia, Lea and Febiger, 1912.
7. Stone, J. S.: Fractures of the External Condyle of the Humerus in Childhood, with Rotation of the Condylar Fragment. Boston Med. and Surg. J., CLXXVI, 151, 1917.
8. Wilson, P. D.: Fractures and Dislocations in the Region of the Elbow. Surg. Gynec. Obstet., LVI, 335, 1933.

Additional Articles

Avellan, W.: Über Frakturen des unteren Humerusendes bei Kindern. Acta Chir. Scandinavica, LXXIII, 1, 1933.

Bates, William: Fractures of Lower End of Humerus. Ann. Surg., XCIX, 1007, 1934.

Beccari, C.: Osservazioni su di un caso di frattura parziale del condilo omerale, con rara associazione di altre lesioni traumatiche del gomito. Arch. di Ortop., L, 853, 1934.

Bergenfeldt, E.: Über Schäden an der Epiphysenfuge bei operativer Behandlung von Frakturen am unteren Humerusende. Acta Chir. Scandinavica, LXXI, 103, 1932.

Best, R. R.: Secondary Ulnar Nerve Paralysis, Report of Case with Fracture of Trochlea. Nebraska Med. J., XI, 433, 1926.

Bonola, A.: Paralisi tardiva dell'ulnare da cubito valgo post-traumatico. Chir. d. Org. di Movimento, XVII, 467, 1932.

Brenken, Max, und Küttner, H.: Die Ulnarisspätlähmung infolge Fraktur des Condylus lateralis humeri. Arch. f. Orthop. u. Unfall-Chir., XXVIII, 182, 1930.

Broca: Décollements épiphysaires et fractures de la région condylienne externe. Rev. Gen. de Clin. et de Thérap., XXVIII, 97, 117, 1914.

Campbell, O. J.: The Treatment of Fractures of the Lower End of the Humerus. Minnesota Med., XVIII, 192, 1935.

Cassiano, H. D.: Fracturas do condylo externo humeral. Tratamento. Evolução. Rev. de Cir. de São Paulo, I, 460, 1935.

Corrêa Netto, A.: Paralisia tardia do nervo cubital conseqüente a frátura do condilo externo do humero; sindroma de Mouchet. Rev. de Cir. de São Paulo, I, 3, 1934.

Delrez, L.: Le traitement des fractures supra-condylaires et fractures du condyle externe chez l'enfant. Arch. Franco-Belges de Chir., XXIX, 880, 1926.

Drew, Douglas: Separation of the Lower Epiphysis of the Humerus, with Displacement. Proc. Roy. Soc. Med., London, IV, Sect. Study Dis. Child., 9, 1910–1911.

Eikenbary, C. F.: Fractures Through the Lower Epiphysis of the Humerus Occurring in Children. J. Am. Med. Assn., LXXXII, 78, 1924.

Eliason, E. L., and McLaughlin, C. W., Jr.: Fractures of Lower End of Humerus Am. J. Surg., XXIII, 79, 1934.

Fabian, E.: Zur Behandlung der Fractura condyli externi humeri mittels Exstirpation des freien Fragments. Deutsche Ztschr. f. Chir., CXXVIII, 409, 1914.

Gregoire, Raymond: Paralysie tardive du nerf cubital à la suite d'une fracture du condyle externe de l'humérus. Bull. et Mem. Soc. Nat. de Chir., L, 232, 1924.

Guibal, P.: Paralysies tardives du nerf cubitale à la suite des fractures du condyle externe. Arch. Franco-Belges de Chir., XXVI, 207, 1923.

Heyl, J. H.: Fracture of External Condyle of Humerus in Children. Ann. Surg., CI, 1069, 1935.

Hunt, J. R.: Tardy or Late Paralysis of the Ulnar Nerve. J. Am. Med. Assn., LXVI, 11, 1916.

Lagoutte et Rousselin, L.: Deux cas de paralysie tardive du cubital consécutives à des fractures du condyle externe de l'humérus. Lyon Chir., XXXII, 239, 1935.

Lang, Carl: Die Behandlungsmethodik und die Heilergebnisse der Brüche des unteren Humerusendes an der Chirurgischen Universitätsklinik zu Königsberg i. Pr. während der letzten 7½ Jahre. Arch. f. Orthop. u. Unfall-Chir., XXXV, 9, 1935.

Lewin, Philip: Pressure Ulnar Palsy. Ulnar Palsy Due to Pressure of a Plaster-of-Paris Body Cast. J. Am. Med. Assn., LXXVIII, 1112, 1922.

Lusena, Gustavo: Le paralisi tardive del nervo cubitale successive a fratture dell'estremo distale dell'omero. Chir. d. Org. di Movimento, VI, 139, 1922.

Moorhead, E. L.: Old Untreated Fracture of External Condyle of Humerus—Factors Influencing Choice of Treatment. Surg. Clin. Chicago, III, 987, 1919.

Pellé, A.: Décalottement du condyle externe de l'humérus passé inaperçu au cours d'un traumatisme du coude. Ablation. Guérison. Rev. d'Orthop., XIX, 48, 1932.

PLATT, HARRY: The Pathogenesis and Treatment of Traumatic Neuritis of the Ulnar Nerve in the Post-Condylar Groove. British J. Surg., XIII, 409, 1926.

On the Peripheral Nerve Complications of Certain Fractures. J. Bone and Joint Surg., X, 403, July 1928.

The Operative Treatment of Traumatic Ulnar Neuritis at the Elbow. Surg. Gynec. Obstet., XLVII, 822, 1928.

ROCHER, H. L., ET GUÉRIN, R.: Luxation ouverte du coude avec fracture du condyle externe. Extirpation du condyle. Résection modelante de l'epiphyse humérale. Paralysie radiale. Guérison. Arch. Franco-Belges de Chir., XXXII, 627, 1930.

ROCHER, H. L., ET ROCHER, C.: Un cas atypique de décalottement du condyle humérale (fracture intraarticulaire du flanc externe du condyle). J. de Med. de Bordeaux, CXII, 397, 1935.

SAITTA, S.: Paralisi tardive del nervo ulnare da frattura del condilo esterno. Ann. di Med. Nav. e Colon., XXXIX, 654, 1933.

SANER, F. D.: Fracture: Separation of the Lower Humeral Epiphysis. Practitioner, CIX, 244, 1922.

SCHALLER, W. F.: Delayed Ulnar Palsy Following Elbow Injury. California State J. Med., XVIII, 302, 1920.

SCUDDER, C. L.: The Treatment of Fractures with Notes upon a Few Common Dislocations. Ed. 10. Philadelphia, W. B. Saunders Co., 1926.

SHELDEN, W. D.: Tardy Paralysis of Ulnar Nerve. Med. Clin. North America, V, 499, 1921.

SMITH, M. K.: Fractures of the External Condyle of the Humerus with Rotation. Ann. Surg., LXXXVI, 304, 1927.

SORREL, E., ET DULOT: Décollement epiphysaire du condyle externe avec rotation de 180° suivant un axe anteropostérieur. Bull. et Mem. Soc. Nat. de Chir., LX, 529, 1934.

SPEED, J. S., AND MACEY, H. B.: Fractures of the Humeral Condyles in Children. J. Bone and Joint Surg., XV, 903, Oct. 1933.

VIOLATO, A.: Le paralisi tardive del cubitale consecutive a frattura del condilo esterno dell'omero. Ann. di Med. Nav. e Colon., I, 314, 1927.

UNUNITED FRACTURES OF THE NECK OF THE FEMUR

BY T. P. McMURRAY, M.B., M.CH., F.R.C.S., LIVERPOOL, ENGLAND
Director of Orthopaedics, Liverpool University

Generations of surgeons have recognized the difficulties met with in the treatment of fractures occurring in the femoral neck. The ingenuity of orthopaedic surgeons has been demonstrated by the widely different methods of treatment which they have advocated, and each of these methods has been successful in promoting bony union in a certain proportion of cases.

Only Whitman's method has been practised for a period sufficiently long to enable the majority of surgeons to understand its limitations, and, in spite of the most careful adherence to the method of choice, failures to obtain union are unavoidable. We are left then with the problem of the unstable hip. Normally the body weight is borne through the line of the sacro-iliac joint and the center of the acetabulum; in the presence of non-union, the support through the thigh is borne at least one and one-half inches to the outer side of this point, so that the center of body weight lies at an equal distance to the inner side. The only method by which the stability of the hip can be restored is by bringing the support again under the normal position of the center of the acetabulum. This may be accomplished by any one of three methods:

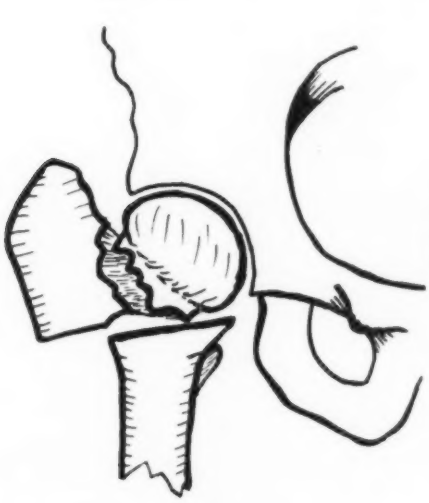


FIG. 1

Drawing from roentgenogram of old ununited fracture, showing absorption of neck, varus deformity, arthritis, line of section of modified Lorenz osteotomy, and displacement of lower fragment.

FIG. 2

Drawing from roentgenogram, showing union of osteotomy site, old fracture, and correction of coxa vara.

FIG. 3

Mrs. S., aged fifty-six years. Preoperative roentgenogram, eight months after accident.

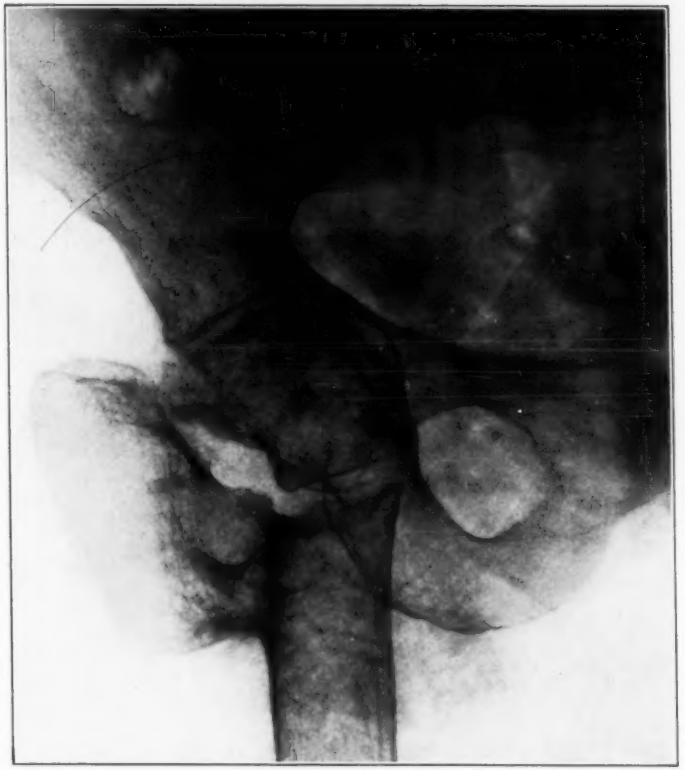


FIG. 4

Mrs. S., aged fifty-six years. Lorenz osteotomy had been performed eight months after the accident. Roentgenogram taken one year later.

1. *Arthrodesis of the hip joint*—a very difficult procedure, entailing great operative risk, and usually resulting in failure.

2. *Reconstruction methods*, as suggested by Whitman and Brackett, in which the remainder of the neck is placed in the acetabulum, with or without removal of the head of the femur, and the greater trochanter is transplanted to a position further down the shaft.

3. *Bifurcation operation*, based on the suggestion of Lorenz, in which the shaft of the femur is transferred directly under the lower margin of the acetabulum and head of the femur.

The author has carried out this last method of treatment in twenty-seven cases of ununited fracture of the neck of the femur; the first of these operations was performed in 1926.

FIG. 5

Mrs. N., aged fifty-seven years. Lorenz osteotomy had been performed nine months after accident. Roentgenogram showing union at site of fracture.

OPERATION

A vertical incision, four to five inches in length, is made over the outer aspect of the femur, starting above at the upper border of the greater trochanter and extending downward along the shaft of the bone. The muscular attachment is freed over the anterior aspect, so that the position of the head of the femur in the acetabulum can be easily defined. An oblique osteotomy (Figs. 1 and 2), extending from below upward and inward, is now made in the shaft of the femur at the level of the lower border of the femoral head, so that the upper border of the lower fragment can be placed *in situ* under the head and lower border of the acetabulum. After the shaft of the femur has been placed in this position, the wound is closed and the position is retained by means of a long plaster spica, for a period of from three to four months until union is complete.

Following the transference of the shaft of the femur to its new position, the upper fragment is drawn inward at its lower border by the muscular attachments which are common to both fragments. This

TABLE I

TWENTY-SEVEN CASES OF UNUNITED FRACTURE OF THE NECK OF THE FEMUR TREATED BY THE MODIFIED LORENZ BIFURCATION OPERATION

Case	Age (*Years*)	Occupation	Date of Fracture	Date of Operation	Preoperative Notes	End Result
A. W. T.	47	Commercial traveler	Jan. 1926	June 1926		Real shortening, 1¼ inches. Patient runs, dances, rides bicycle, walks miles. Motion in hip to within 30 degrees of full flexion. Patient well satisfied.
Mrs. S. S.		Shopkeeper	Dec. 1927	Jan. 1929	Real shortening, 1 inch.	Real shortening, 1¾ inches. Motion in hip to within 20 degrees of full flexion. Other movements normal. Patient working, as active as ever.
Miss A. L.	46	School teacher	Nov. 1927	March 1930	Real shortening, 1½ inches.	Real shortening, 1¾ inches. Motion in hip to within 20 degrees of full flexion. Good abduction. No rotation. Knee flexes to within 25 degrees of normal; aches after use. Patient is working.
E. L.	36	Laborer	Feb. 1929	June 1930		Real shortening, 1½ inches. Some abduction; 60 degrees of flexion. Knee flexes to 50 degrees. Patient walks some miles, but has not been able to resume his original occupation.
Mrs. S. S.	58		June 1929	July 1930	Real shortening, 1¾ inches.	Real shortening, 2 inches. Patient walking well and very well satisfed.
R. B.	45	Miner	June 1929	Sept. 1930	Real shortening, 1 inch.	Real shortening, 1½ inches. Motion in hip 25 degrees short of full flexion. Other movements normal. Patient walks miles, but cannot sit on heels, so is unable to return to work as miner.
Mrs. M. D.	52	Housewife	Sept. 1929	Sept. 1930	Real shortening, ¾ inch.	Real shortening, 1 inch. Hip flexes to well past a right angle, but gets tired at end of day. Other movements normal. Patient well satisfed.
Mrs. P.	63	Housewife	Jan. 1930	Oct. 1930	Real shortening, 1¼ inches.	Generalized rheumatism has developed. Patient can now stand more easily on the leg which has been operated upon than on the other leg.
J. H. J.	27	Actor	Jan. 1930	Jan. 1931	Real shortening, 1½ inches.	Patient did not return. Wrote that his condition was excellent and that he was working.

Mrs. A. W.	58	Housewife	May 1930	Nov. 1931	Real shortening, 1¼ inches.	Real shortening, 1½ inches. Hip shows 60 degrees of flexion, fair abduction, no rotation. Patient walks well and is working.
E. Q.	51	Mill hand	Feb. 1931	Sept. 1931		Flexion to 90 degrees in knee and hip. Pain in hip after use. Patient walks well.
J. B.	52	Miner	Feb. 1931	Jan. 1932	Real shortening, ¾ inch.	Real shortening, 1½ inches. Active flexion very limited; passive flexion of 20 degrees. Patient walks with a dip. Hip unstable and painless. X-ray shows bad result.
Mrs. Y.	56	Housewife	Jan. 1932	Sept. 1932		Real shortening, 1½ inches. Flexion to a right angle. No pain. Patient able to do washing and housework. Walks well and is very well pleased.
Mrs. N. R.	62		Apr. 1931	Oct. 1932	Real shortening, ½ inch.	Plaster removed in February 1933. Patient not seen again.
Miss E. J.	65	Housekeeper	Apr. 1931	Oct. 1932	Real shortening, 1½ inches.	Real shortening, 1½ inches. Patient walked fairly well, but fell downstairs a year after operation and twisted the knee and foot. Since that time, patient has not regained confidence in walking.
Mrs. B.	53	Housekeeper	Sept. 1932	Jan. 1933		Flexion in knee of 15 degrees. Patient had oedema of both legs and thighs, which gradually diminished, but she could not be persuaded to discard the crutches or to walk out of doors.
T. P.	60	Unemployed	July 1932	July 1933	Real shortening, 1½ inches.	Real shortening, 2 inches. Free flexion of 45 degrees. No pain. Patient able to walk miles and is well pleased.
Mrs. N.	58	Waitress	March 1933	Dec. 1933	Real shortening, 1 inch. Only 20 degrees of flexion.	Real shortening, 1½ inches. Hip shows 30 degrees of free flexion, poor abduction, no rotation. Patient cannot climb stairs and is not working.

TABLE I (*Continued*)

Case	Age (*Years*)	Occupation	Date of Fracture	Date of Operation	Preoperative Notes	End Result
Mrs. P.	58	Nurse	Jan. 1933	Apr. 1934	Real shortening, 2 inches. Hip very painful.	Real shortening, 3 inches. Flexion to 80 degrees. Some abduction. Patient walks fairly well, but is not working. (Postencephalitic.)
Mrs. S.	57		Jan. 1934	May 1934	Real shortening, 1 inch.	Plaster removed in September 1934. Patient did not return.
Dr. S.	47	Physician	Jan. 1933	May 1934	Real shortening, 1½ inches.	Real shortening, 1½ inches. Good movements, no pain. Patient walking well and is working.
J. T.	54		Feb. 1933	June 1934	Real shortening, 1¾ inches.	October 1935, real shortening, 2 inches. No pain. Patient walks 2 miles easily. X-ray shows good result.
F. V.	47		Feb. 1918	July 1934	Real shortening, 2 inches.	Real shortening, 2 inches. Patient much improved, walks ¾ of a mile, becomes tired easily. X-ray shows good result.
Mrs. M.	55		May 1934	Sept. 1934	No shortening.	In March 1935, the patient was fitted with a canvas hip shield. Is making good effort at walking.
T. N.	58	Laborer	Sept. 1933	Oct. 1934	Real shortening, 1 inch. Patient had a fractured pelvis.	Real shortening, 2 inches. Flexion in hip to 35 degrees. Knee flexes to right angle. Patient has no pain, walks well with limp, is doing light work.
J. J.	28	Clerk	Dec. 1933	Oct. 1934	Real shortening, 1½ inches.	Real shortening, 2 inches. Hip shows flexion to a right angle, full abduction, fair rotation. Patient would like a little more flexion. He plays football and is unemployed.
Mrs. S.			Sept. 1933	Nov. 1934	Real shortening, ¾ inch.	Patient walks badly, is very neurotic and worried. X-ray shows excellent result.

FIG. 7

J. B., aged forty-five years. Postoperative roentgenogram, showing that the site of the osteotomy was too high. The result was a failure.

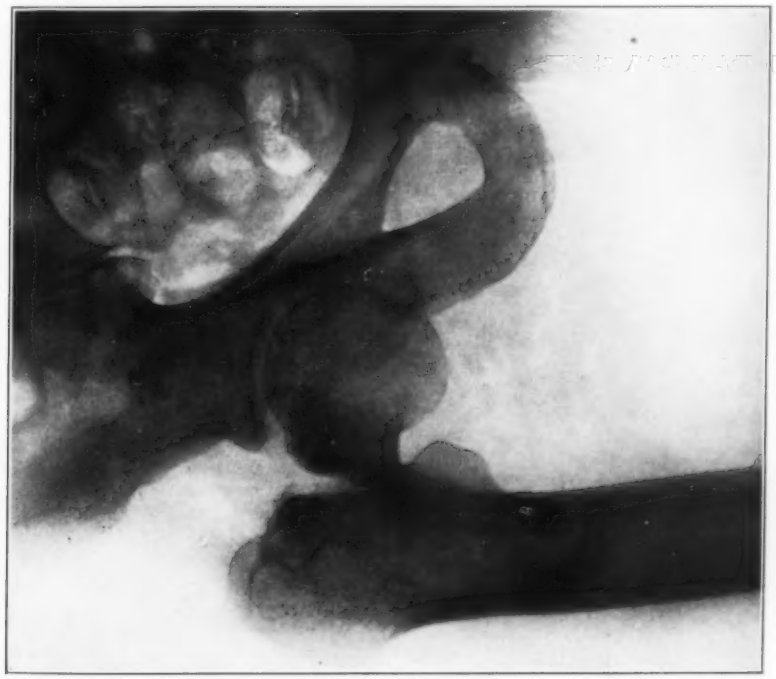


FIG. 6

J. B., aged forty-five years. Preoperative roentgenogram, fifteen months after accident.

FIG. 8

Mrs. Sh., aged fifty-seven years. Preoperative roentgenogram, one year after accident.

FIG. 9

Mrs. Sh. Postoperative roentgenogram. Osteotomy had been performed one year after the accident and the roentgenogram was taken three years later.

tilting inward of the upper fragment prevents the separation of the two raw divided surfaces and predisposes to union, which is essential for the production of a stable hip (Figs. 3 and 4). Occasionally, even in fractures which have remained ununited for a long period, union between the head and the greater trochanter occurs following this operation on account of the alteration of weight bearing (Fig. 5). In these circumstances, the stability of the joint is greatly increased and no permanent disability remains.

There are certain errors into which the surgeon may fall in the course of this very simple procedure. If the osteotomy is carried out at too high a level, the transference of the shaft of the femur under the head and acetabulum cannot take place, and the operation fails in its object (Figs. 6 and 7). Again, if the osteotomy is performed at too low a level, no weight is borne directly through the shaft of the femur, so that the strain at the site of non-union remains unaltered.

The object of making the osteotomy oblique is simply to make certain that union occurs between the divided fragments. If a transverse osteotomy is done, the result is excellent, but there is a grave risk of separation of the two portions of the femoral shaft, resulting in non-union.

If the osteotomy is performed at a very acute angle, the upper end of the shaft of the femur is so pointed that fracture of this margin may occur, as happened in one of the author's cases.

The essentials for success in this type of treatment are:

1. Correct position of the transferred shaft of the femur under the acetabulum and femoral head. (See Figures 8 and 9.)
2. Union between the divided fragments of the shaft of the femur, without which the hip joint remains flail and painful.
3. A position of very slight abduction, in order to prevent the development of a subsequent knock-knee deformity.

The advantages of this form of treatment are:

1. Its simplicity and the absence of shock which is of great importance in elderly patients.
2. The comparative certainty of relief in contrast with many of the other procedures whose advantages are problematical.
3. The fact that the operation may be performed in spite of a very long interval of non-union.
4. No necessity for any form of walking splint following the removal of plaster.

HEMATOGENOUS ACUTE OSTEOMYELITIS IN CHILDREN *

BY JOHN C. WILSON, M.D., AND FRANCIS M. McKEEVER, M.D.,
LOS ANGELES, CALIFORNIA

One hundred and ten patients suffering from hematogenous acute osteomyelitis, exclusive of the bones of the head and the face, were admitted to the Orthopaedic Department of the Children's Hospital during the six-year period from June 1928 to June 1934.

An effort has been made to determine the effect upon the patients of early and late operations with regard to the mortality and development of secondary foci.

CLASSIFICATION

The character of the pathological changes of the bones, as determined by roentgenographic studies, places these patients in four groups:

1. Multiple diffuse type—thirty-four cases;
2. Single diffuse type—sixty-four cases;
3. Circumscribed type (Brodie's abscess)—eight cases;
4. Sclerosing osteomyelitis—four cases.

FATAL CASES

Exclusive of the two groups of circumscribed (Brodie's abscess) and

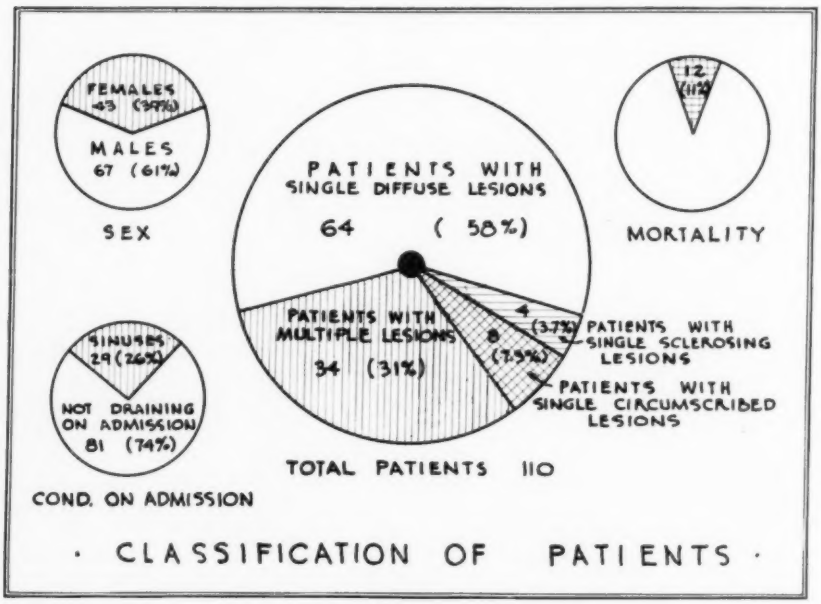


FIG. 1

* Read in part before the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

sclerosing bone infections, in which there were no fatalities, there were ninety-eight instances of single and multiple diffuse bone infection. Twelve, or 12.2 per cent., of these ninety-eight patients died.

A discussion of the patients who died must be directed chiefly toward a retrospective study of the propriety of operative interference. These patients were attacked surgically at varying periods in the course of the disease: six within the first week; three during the second week; and three between the sixteenth and twenty-third day following the onset of the infection.

Surgical Treatment

Operations entailing resection of bone to obtain drainage were done in seven patients. In the remaining five patients, soft-tissue abscesses developed, which were drained without an attempt to expose or to explore the underlying bony structures.

The precarious condition of the patients in both of these groups was manifested by the development of the following serious complications:

1. Bronchopneumonia—three cases;
2. Bacterial endocarditis—two cases;
3. Brain abscess—one case;
4. Meningitis—one case;
5. Lateral sinus thrombosis—one case.

Interval between Operation and Death

Six patients (50 per cent.) died within the first week, and five of these within the first twenty-four hours after operation. One death should be considered a surgical accident, as the autopsy revealed a large pulmonary embolus. Two patients died during the second week, three within the next eight days, and one survived for 220 days. Such a high mortality within a short postoperative period must cause grave reflection as to the most appropriate time for operation. We are of the opinion that this investigation and other studies indicate that operative interference may well be and often is undertaken too early rather than too late in the course of the disease.

TREATMENT

The recent text-books on surgery impress the reader with the fact that a focus of hematogenous acute osteomyelitis must have immediate drainage. In fact, one should arise in the middle of the night to drain these areas because of the danger of rapid dissemination of infection and its products, thought to be under mechanical pressure. To wait for roentgenographic evidence of localization is classed as gross neglect.

Ninety-eight patients, with single or multiple diffuse lesions, none of which were Brodie's abscesses or infections of the sclerosing type, may be discussed with regard to the time of surgical drainage. Four patients were classified as undetermined because the histories were incomplete

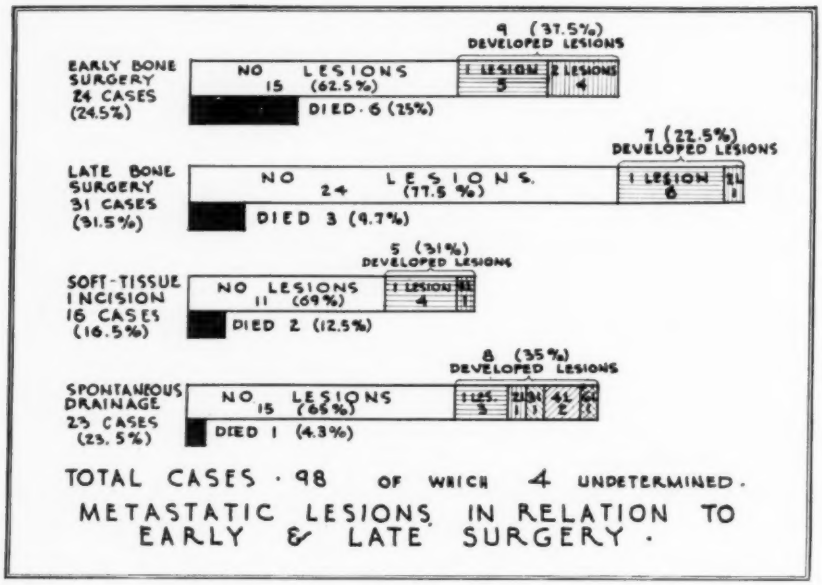

9 (37.5%) DEVELOPED LESIONS
EARLY BONE SURGERY 24 CASES (24.5%)
NO LESIONS 15 (62.5%)
1 LESION 3
2 LESIONS 4
DIED 6 (25%)
7 (22.5%) DEVELOPED LESIONS
LATE BONE SURGERY 31 CASES (31.5%)
NO LESIONS 24 (77.5%)
1 LESION 6
DIED 3 (9.7%)
5 (31%) DEVELOPED LESIONS
SOFT-TISSUE INCISION 16 CASES (16.5%)
NO LESIONS 11 (69%)
1 LESION 4
DIED 2 (12.5%)
8 (35%) DEVELOPED LESIONS
SPONTANEOUS DRAINAGE 23 CASES (23.5%)
NO LESIONS 15 (65%)
DIED 1 (4.3%)
TOTAL CASES · 98 OF WHICH 4 UNDETERMINED.
METASTATIC LESIONS IN RELATION TO EARLY & LATE SURGERY.

FIG. 2

and these individuals could not be located for an examination to determine accurately the end results. The remaining ninety-four patients may be grouped in four divisions, according to the type of treatment.

Group I—Early Surgical Drainage

This group comprised twenty-four patients in whom drainage of the medullary canal at the site of the bone infection was done within the first seven days of the disease. In these patients drainage was done before roentgenographic evidence of osteomyelitis was present, and in many of them the recovery of bacteria furnished the only evidence of infection.

Group II—Delayed Surgical Drainage

This group included thirty-one patients in whom the medullary cavity was drained during the period from the seventh to the twenty-eighth day of illness. A majority of these patients showed roentgenographic evidence of disease. Pus was found in all and in many there was a subperiosteal or soft-tissue abscess. At this point we wish to state that in our opinion a comparison between Groups I and II is justified because, by and large, the patients comprising Group II (which is the larger group) were in general as acutely and desperately ill as the patients in Group I and, according to the old dictum, "demanded" operation as definitely as those in Group I.

Group III—Incision of Soft Tissues

In this group were sixteen patients in whom only a soft-tissue in-

cision was made. This type of operation was for the most part performed by the practitioner in the home, and these patients entered the hospital with one or more draining sinuses and roentgenographic evidence of osteomyelitis.

Group IV—Spontaneous Drainage

This group of twenty-three patients included those who had had neither surgical drainage of the bone nor incision of the soft tissues. The abscesses perforated the skin spontaneously. On admission to the hospital, each of the patients had one or more draining sinuses and roentgenographic evidence of osteomyelitis.

FINDINGS

Mortality

A comparison of the mortality rates reveals that it was highest in Group I. Six, or 25 per cent., of these twenty-four patients who had early adequate drainage of the medullary canal within seven days of the onset of illness, died. There were no macroscopic changes suggestive of osteomyelitis, and in many cases there was only bacteriological or microscopic evidence of infection. Three of these deaths (50 per cent.) occurred within forty-eight hours after the operation, which was not unduly prolonged, radical, or complicated by hemorrhage.

The medullary canal was drained between the seventh and twenty-eighth days of illness in the thirty-one patients of Group II. Three of these thirty-one patients, or 9.7 per cent., died. These patients had intramedullary subperiosteal or soft-tissue abscesses. A large percentage also had some roentgenographic evidence of bone infection.

The mortality rate dropped 15 per cent. when medullary drainage was carried out after the first week of the illness.

The lowest mortality was in Group IV, the patients in whom the abscesses drained spontaneously. Only one of these twenty-three patients, or 4.3 per cent., died and this death resulted from a complication, a staphylococcus meningitis which developed four months after a sequestrectomy. This group does not offer an adequate comparison because the acute phase of the illness took place before admission to the hospital and no records or accurate observations of the virulence of the infection are available. We have been unable to escape the impression, however, that the "dilatory, inefficient" treatment in many instances probably saved the lives of some of these patients, which is after all a matter of some importance. Groups I and II are comparable because the acute phases of the illness were observed and recorded.

Metastatic Lesions

In Group I, nine of the twenty-four patients (37.5 per cent.) developed metastatic lesions. Two of these nine patients had a metastatic lesion within forty-eight hours after surgical drainage. Subperiosteal abscesses

were not present at operation. The maximum number of metastatic lesions was two. This number of lesions was found in four patients in this group.

In Group II, where the medullary canal was drained after seven days, metastatic lesions developed in seven of the thirty-one patients (22.5 per cent.). The maximum number of two lesions occurred in only one patient.

Group III was made up of sixteen patients who had only drainage of abscesses which had ruptured in the soft tissues. Of these, five (31 per cent.) developed metastatic lesions. In four there was one secondary focus of infection, and in one there were five secondary foci of infection.

In Group IV, where no surgery was done but spontaneous drainage took place, eight of the twenty-three patients (35 per cent.) developed metastatic lesions, and in this group the incidence of multiple metastatic infections was materially increased. One patient developed two metastatic abscesses; one had three; two developed four; and one had six.

CONCLUSIONS

These findings suggest that perhaps the answer to the problem is not the earliest possible surgical invasion of the bone, but a well-timed adequate drainage of the medullary canal when the individual's resistance is at the highest possible point.

It has been our repeated experience that an acutely suffering child, who enters the wards in a badly dehydrated condition with a very high temperature and pulse rate, will become a vastly better operative risk in twenty-four, forty-eight, or even seventy-two hours, during which the suffering has been relieved and the dehydration overcome. The improvement in the general condition will be obvious and the chart will confirm this impression. The lesion will probably be quite evident when the child enters the hospital, as will the eventual necessity for an operative procedure, but timing is the important factor in treating acutely sick children. A blood-borne infection of bone may be more successfully handled by adhering to the principle of allowing the infection to localize. A catastrophe may result from a too early ostectomy of an infected bone, for the same reason that incision of a brawny cellulitis is often fatal.

On the other hand, it seems unwise negligently to permit an individual to harbor a well-formed abscess for days, or to drain such an abscess only partially and imperfectly. Such procedures are favorable to the formation of multiple metastatic lesions, as is evidenced by the preponderance of these lesions in cases where only incision of the soft tissues was carried out, or those in which spontaneous rupture of the abscesses was permitted.

THE HEALING OF SEMILUNAR CARTILAGES *

BY DON KING, M.D., F.A.C.S., SAN FRANCISCO, CALIFORNIA

From Division of Orthopaedics, Department of Surgery, Stanford University School of Medicine

The semilunar cartilages have a very limited blood supply. By arterial injection with an opaque medium,† one can discern a network of fine vessels from the capsule, entering the convex border of the meniscus but disappearing almost immediately. Because of this, one might expect healing in peripheral meniscus detachments, but none in tears limited to the semilunar cartilage itself. This paper is a report of our experiments on the healing of peripheral detachments,—longitudinal and transverse incisions in the internal semilunar cartilages of the knees of dogs.

In each case, the knee joint was opened by a curved incision, the internal lateral ligament being cut in some instances. No postoperative fixation was used and, with one exception (Dog 11), all the dogs ran about in a perfectly normal way within a few days after the operation.

Dog 1

The anterior half of the internal semilunar cartilages of both knees was freed peripherally from its capsular attachment (Fig. 1). One hundred days later, the animal was sacrificed and the knee joints were opened. There was not the slightest evidence of meniscus displacement or, in fact, of any pathology. The semilunar cartilages were perfectly healed to the capsule.

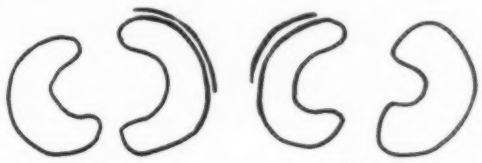


FIG. 1

Dog 1. Drawings illustrating incisions.

Dog 2

Left knee: The anterior half of the internal semilunar cartilage was incised longitudinally, the incision beginning laterally at the capsular attachment (Fig. 2-A).

Right knee: In addition to the longitudinal incision (Fig. 2-A), the posterior half of the cartilage was freed from its capsular attachment.

Sixty days later the joints were opened and the findings (Fig. 2-B) were as follows:

Left knee: The posterior half of the meniscus was normal. The external fragment of the anterior half was completely covered with connective-tissue pannus growing in from the capsule. This pannus had attached itself to the medial fragment and held it snugly in place so that there was no danger of displacement.

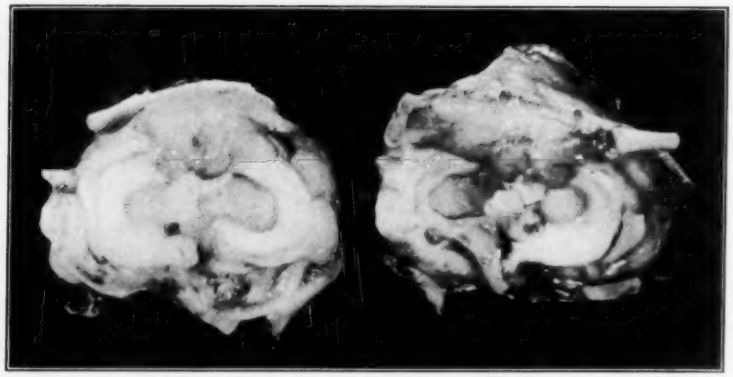
Right knee: Here again the two halves of the anterior portion had been glued together by connective-tissue pannus, from

FIG. 2-A

Dog 2. Drawings illustrating incisions.

* Received for publication September 5, 1935. The material in this paper was presented at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

† Poth's modification of Hill's radiopaque mass is very satisfactory for this purpose.[1]



Left Right

FIG. 2-B

Dog 2. Note granular degeneration of the internal articular cartilages. The anterior longitudinal incisions healed by pannus formation from the synovial membrane laterally. Broad bands of scar tissue are seen holding the posterior horn of the right meniscus to the synovial membrane.

Left Right

FIG. 3

Dog 3. Drawings showing incisions.

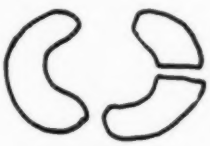


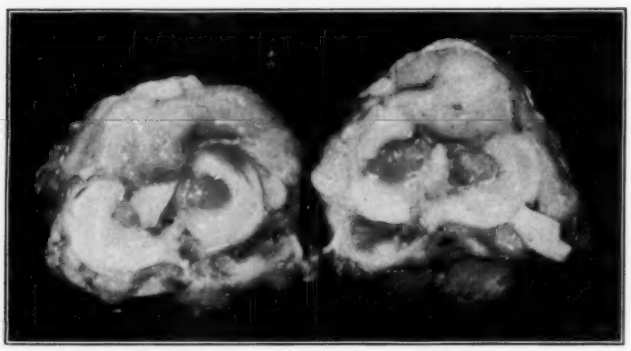
FIG. 4

Dog 4. Drawing showing transverse division of the internal meniscus of the left knee.

Left Right

FIG. 5-A

Dog 5. Drawings illustrating incisions.



Left Right

FIG. 5-B

Dog 5. Forty-two days after operation. The longitudinal incision has healed anteriorly but not posteriorly. The transverse incision is filled in with connective tissue.

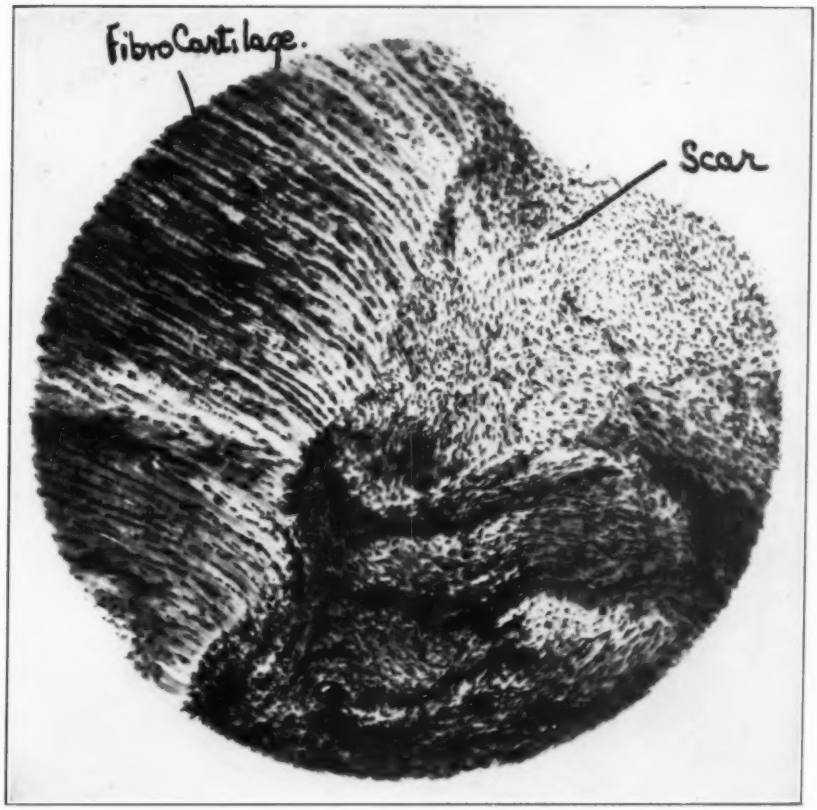


FIG. 5-C

Photomicrograph of coronal section through incision of right knee, showing junction of meniscus stump with the scar tissue. This tissue arises laterally from the synovial membrane and contains no cartilage.

the synovial membrane, which had grown across the external half into and filling the incision. The posterior half of the meniscus was narrowed and yellowish, and was connected with the synovial membrane posteriorly by broad bands of scar tissue.

There was also an early granular degeneration of the internal tibial articular cartilages.

DOG 3

Left knee: A short longitudinal incision was made in the anterior half of the external portion of the internal meniscus (Fig. 3).

Right knee: A short longitudinal incision was made, as in the left knee, but communicating with the capsule laterally (Fig. 3).

Sixty days later, the incision in the left meniscus was unhealed, while that in the right, which communicated with the capsule, had healed perfectly.

FIG. 6-A

Dog 8. Drawings illustrating incisions.

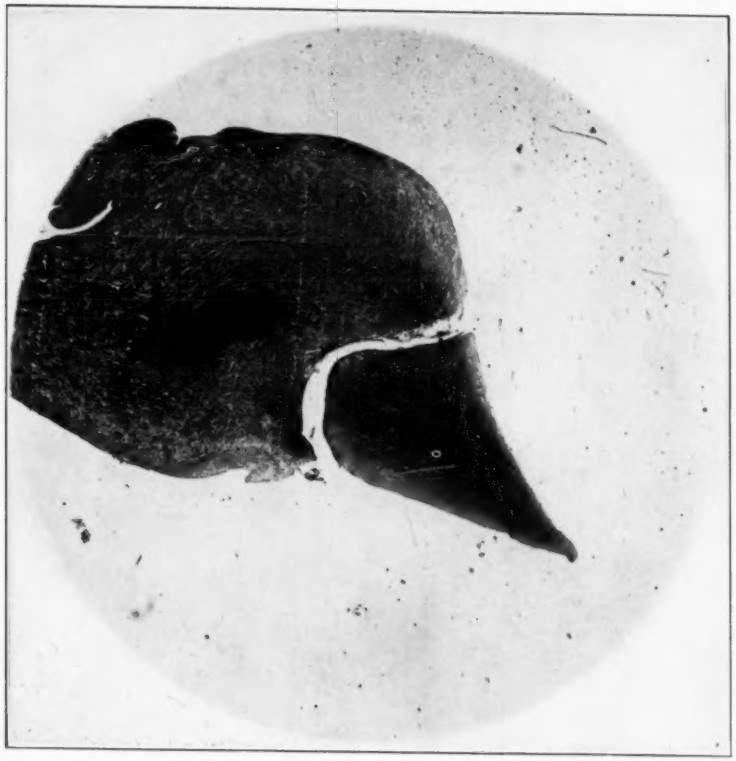


FIG. 6-B

Dog 8. Transverse section of internal semilunar cartilage, showing unhealed incision. The edges of the incision are covered with fibrin.

FIG. 6-C

Dog 8. Transverse section through the incision taken posteriorly where it does not completely penetrate the meniscus. There is no evidence of healing. Edges of incision are covered with fibrin.

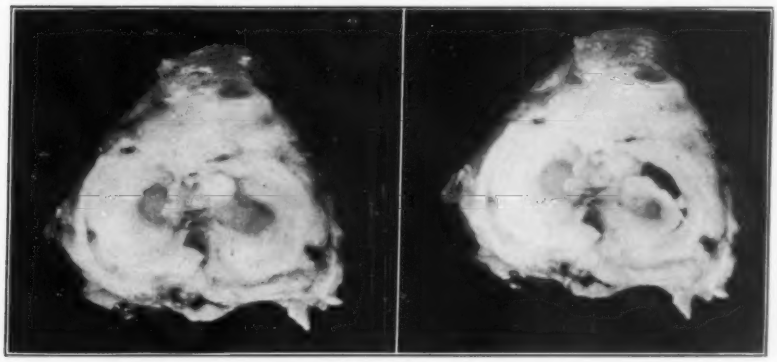


FIG. 7-A

Dog 9. Left knee, showing perfect apposition of the fragments of the internal semilunar cartilage.

FIG. 7-B

Dog 9. Left knee, twenty-three days after operation. The fragments are separated, and there is no evidence of healing.

DOG 4

The internal meniscus of the left knee was divided transversely (Fig. 4). Two weeks later the two fragments were joined by young connective tissue arising from the synovial membrane and capsule laterally.

DOG 5

Left knee: The anterior half of the internal meniscus was freed from its capsular attachment and split longitudinally (Fig. 5-A), the anterior end of the incision being external at the old capsular attachment.

Right knee: The internal meniscus was divided transversely (Fig. 5-A), just anterior to the internal lateral ligament.

Forty-two days later, the following conditions were noted:

Left knee: The meniscus was reattached to the capsule. The anterior end of the longitudinal incision was filled with connective tissue which welded the two fragments together. The posterior end of the incision was unhealed. (See Figure 5-B.)

FIG. 7-C

Dog 9. Frontal section through joint of right knee, showing at left the unhealed meniscus twenty-three days after longitudinal incision; at right, normal external meniscus. In the center, the stump of the anterior cruciate ligament can be seen.

FIG. 7-D

Dog 9. Photomicrograph of incision through the internal semilunar cartilage of the right knee twenty-three days after operation. There is no evidence of healing or of necrosis of the internal fragment.

Right knee: The two halves of the cartilage were separated by about two millimeters. This space was occupied in its peripheral two-thirds by a yellowish granulation tissue which held the two halves firmly together. (See Figures 5-B and 5-C.)

Dog 6

The medial two-thirds of the internal menisci were freed from the capsule peripherally. Forty days later, perfect healing had occurred.

Dog 7

Both internal menisci were divided transversely. Twenty-one days later, the cut surfaces were found to be separated by about two millimeters, the space being filled with scar tissue growing in from the synovial membrane at the periphery.

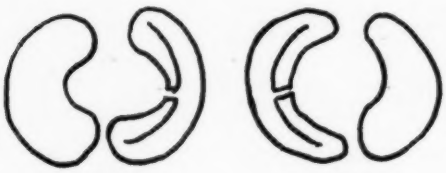


FIG. 8

Dog 10. Longitudinal incision plus transverse incision in mesial fragment.

Dog 8

Left knee: The internal meniscus was incised longitudinally through the greater part of its length. It was also freed peripherally, with the exception of the attachments of the anterior and posterior horns. (See Figure 6-A.)

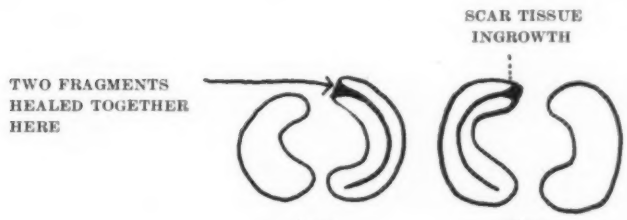


FIG. 9

Dog 11. Thirty days after operation.

Right knee: The capsular attachment was severed, except for that of the tips of the anterior and posterior horns (Fig. 6-A).

Fourteen days later the dog was sacrificed and the following observations were made:

Left knee: The joint contained considerable turbid fluid with large bits of fibrin. The synovial membrane was deeply congested. (Smears from the fluid showed a moderate number of pus cells; the cultures were negative.) Anteriorly, the longitudinal incision was glued together by pannus which had grown inward from the synovial membrane over the peripheral fragment. Posteriorly, the incision was glued together with fibrin, but no true healing had occurred (Fig. 6-C).

Right knee: There was a small amount of clear fluid in the joint, with slight congestion of the synovial membrane. The meniscus was very well healed in its normal anatomical position.

Dog 9

A longitudinal incision was made through the greater part of the internal semilunar cartilage of each knee, care being taken to keep the incision in the middle third.

Twenty-three days later the knee joints were opened. The two fragments of the cartilages were lying next to each other in perfect apposition (Fig. 7-A), but could be separated with ease, there being no evidence of healing (Figs. 7-B, 7-C, and 7-D).

Dog 10

The internal semilunar cartilages were incised longitudinally and the internal fragment was divided transversely as shown in Figure 8.

Twenty-six days later, the fragments were found to be perfectly apposed. There was not the slightest evidence of healing, however.

Dog 11

The internal cartilages were split longitudinally, the anterior ends of the internal fragments being completely separated from the transverse ligaments.

Thirty days later, the two fragments were in perfect apposition. At the anterior ends they

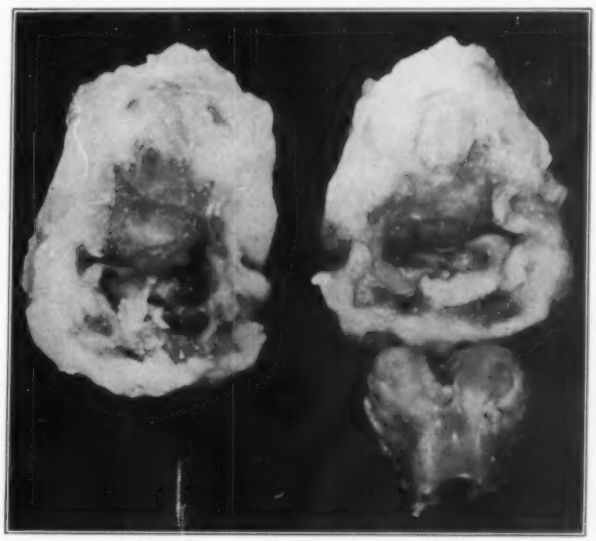


FIG. 10

Dog 12. Forty-two days after operation. Note the marked pannus formation, synovial thickening, and articular-cartilage degeneration. The anterior portions of the internal menisci had degenerated and were incorporated in pannus.

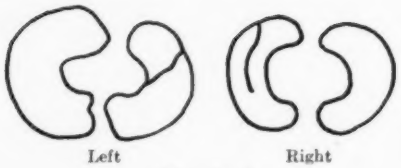


FIG. 11-A

Dog 13. Drawings illustrating incisions.

were firmly united by a connective-tissue ingrowth from the synovial membrane (Fig. 9).

DOG 12

The internal cartilages were incised longitudinally, as in the case of Dog 11. For three weeks following the operation, the animal refused to stand. Both knees were somewhat swollen, but not locked. After he had begun to stand, he walked with great difficulty, bearing practically no weight on the right hind leg. Forty-two days after operation, at the time of sacrifice, the animal was walking around, but still limped badly.

Both knees contained a moderate amount of clear fluid. The synovial membrane was thickened, and a great deal of pannus covered the cruciate ligaments and the peripheral margins of the semilunar cartilages, the internal menisci being lusterless and yellow. Anteriorly, where incised, the two fragments were incorporated in a syncytium of connective tissue streaming in from the synovial membrane. The medial articular cartilages of the tibia had degenerated, and, on the right side, there was an area of degeneration on the anterolateral aspect of the lateral femoral condyle. It is impossible to explain this advanced degree of degeneration. (See Figure 10.)

DOG 13

Left knee: The internal semilunar cartilage was divided obliquely across at the level of the internal ligament (Fig. 11-A).

Right knee: The cartilage was split longitudinally, the incision beginning anterolaterally at the synovial membrane (Fig. 11-A).

Fifteen days later, the joints were opened and the findings were as follows:

Left knee: The two halves of the cartilage were separated by about two millimeters. This space was well filled with connective tissue originating from, and directly continuous with, the synovial membrane laterally (Fig. 11-B).

FIG. 11-B

Dog 13. Left knee, fifteen days after operation, showing scar tissue welding the two stumps together.

Right knee: The synovial membrane had given origin to a connective-tissue ingrowth into the anterior end of the incision for a distance of about two millimeters. The major portion of the incision showed no evidence of healing.

DOG 14

Longitudinal incisions were made in the internal cartilage of each knee, communicating with the synovial membrane anterolaterally (Fig. 12-A). Postoperative recovery was uneventful in every way and, at the time of sacrifice (fifteen days later), the animal appeared normal. There was no evidence of locking at any time.

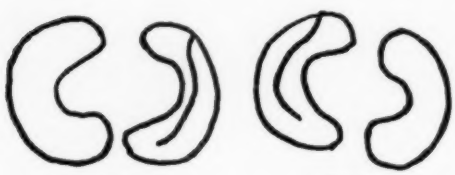
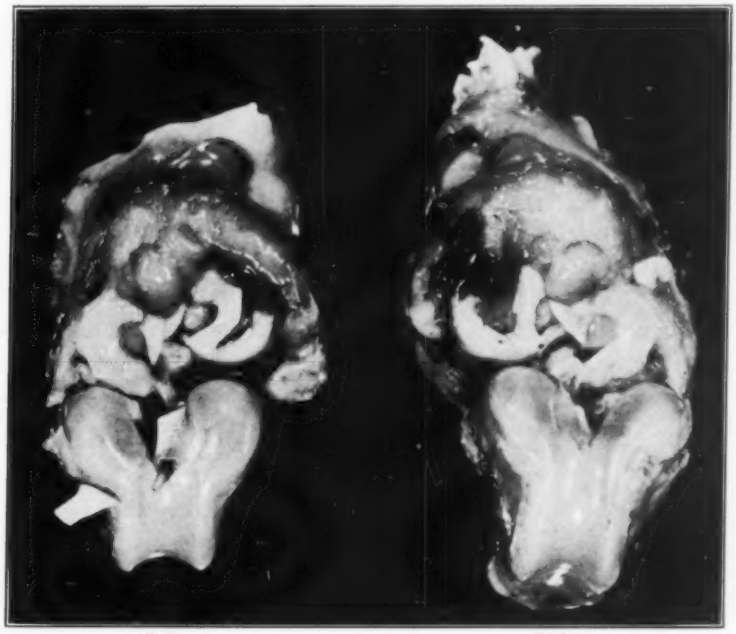


FIG. 12-A

Dog 14. Drawings illustrating incisions.

Left knee: The internal fragment was displaced medially and twisted upon itself. Anteriorly, a heavy growth of deeply congested pannus held the two fragments together (Fig. 12-B).

Right knee: The internal fragment was displaced farther into the joint, but had not undergone volvulus. Otherwise, the condition was the same as that of the left.



Left Right

FIG. 12-B

Dog 14. Fifteen days after operation. Note displacement of internal fragments. The heavy growth of pannus appears black in the photograph.

SUMMARY AND CONCLUSIONS

In seven knee joints of dogs, the internal semilunar cartilages were freed, to a varying extent, from their attachments to the synovial membrane and capsule peripherally. Within a few days, the dogs walked and ran about in a normal way; no locking of the joints was produced. After a period of time (two weeks to three and a half months), the animals were sacrificed and the joints were examined. In each case, the cartilage was firmly healed in normal anatomical position.

In thirteen joints, the semilunar cartilages were incised longitudinally. In each case the incision did not communicate with the synovial membrane and varied in its position in the cartilage. With one exception (Dog 14), the two fragments of the semilunar cartilages remained closely apposed although no postoperative fixation was used. In spite of this close apposition, there was not the slightest evidence of healing between the fragments during the period of observation (three weeks to two months).

In seven joints, the longitudinal incision was carried through the convex edge of the meniscus to the synovial membrane. In each case, the peripheral end of the incision healed by connective tissue arising from the

synovial membrane and capsule. In one instance (Dog 3), the entire incision was filled with scar tissue.

When the semilunar cartilage was divided transversely (in six joints), the two fragments were separated a short distance. The free space thus produced was obliterated by an ingrowth of connective tissue from the synovial membrane, linking the two fragments firmly together. This connective tissue, which grossly resembled fibrocartilage, contained no cartilage cells.

Our experiments indicate that:

1. Tears which are limited to the semilunar cartilage probably never heal.

2. A torn meniscus can be healed by connective tissue if the tear communicates with the synovial membrane laterally.

3. A complete transverse or oblique tear results in some separation of the fragments, but the intervening space fills in with connective tissue arising from the synovial membrane. This connective tissue is quite firm in three weeks, which suggests the length of time necessary for complete fixation in these cases.

4. If the meniscus is partially torn from its peripheral attachment, it heals in normal anatomical position without difficulty.

1. Poth, E. J.: A Modification of Hill's Radiopaque Mass for the Injection of Lumina. J. Lab. and Clin. Med., XIX, 1241, 1934.

PYOGENIC OSTEOMYELITIS OF THE SPINE

An Analysis and Discussion of 102 Cases

BY JACOB KULOWSKI, M.D., F.A.C.S., ST. JOSEPH, MISSOURI

From the Departments of Orthopaedic and General Surgery, State University of Iowa, Iowa City, Iowa*

INTRODUCTION

Although pyogenic osteomyelitis of the spine is generally considered to be relatively uncommon, numerous case reports and descriptions of the disease have been published. More recently, benign forms have been recognized, due to extended experience and more discriminating diagnoses. These forms, almost without exception, have been considered as tuberculous in the past, in spite of the well-known greater incidence of pyogenic bone and joint lesions in general. It is significant that the ratio of tuberculous spondylitis to pyogenic osteomyelitis has been but two to one, during the past three years in the Orthopaedic Clinic at Iowa City, since interest in pyogenic lesions has been aroused.† *All septic patients should be watched for spinal complications and, if such patients die, the entire spine should be examined at autopsy.*

Pyogenic osteomyelitis of the spine differs from other more common localizations of the disease chiefly because of its relatively vulnerable anatomical situation. Therefore, the primary lesion is often overlooked or subordinated to the more extensive secondary purulent infiltrations in the adjacent vital organs and body cavities, which are characteristic of the disease.

This series includes sixty instances of pyogenic spondylitis observed up to September 1934 at the University Hospitals, Iowa City—3.94 per cent. of the total series of 1,500 cases of pyogenic osteomyelitis—and forty-two cases obtained by questionnaire. The total number of cases reported in the literature, including the present group, is well over 300.

INCIDENCE (TABLE I)

In the questionnaire series, males predominated in the usual ratio of about two to one. It is of particular interest to note that this was considerably higher in the Iowa series. Pyogenic spondylitis is not primarily a disease of the growing period. The majority of these cases occurred after the third decade, when the spine is completely formed. Instances of the disease have been reported in very young children, but not in infants. The striking incidence of pyogenic spondylitis in adults, in contrast to the predilection of osteomyelitis in its long bone manifesta-

* Services of Arthur Steindler, M.D., and H. L. Beye, M.D.
† Personal communication from Ernst Freund, M.D.

TABLE I

AGE AND SEX INCIDENCE OF PATIENTS WITH PYOGENIC SPONDYLITIS

Incidence	Iowa Series	Questionnaire Series	Total
Sex:			
Males	46	28	74
Females	14	14	28
Age:			
Youngest	8 years	12 years	10 years
Oldest	62 years	58 years	60 years
Average	31 years	31 years	31 years
Decade:			
First	1	0	1
Second	19	13	32
Third	8	7	15
Fourth	12	9	21
Fifth	11	3	14
Sixth	5	6	11
Seventh	4	0	4
Total	60	38 *	98

* In four cases in this series, the ages were unknown.

tions for children, may be in part accounted for by the lack of true epiphyseal growth of the vertebrae, persistence of rich cellular bone marrow, and sluggish voluminous blood supply. The latter condition aids the early transport of organisms and thrombo-embolic processes in the vertebral bone marrow in bacteriemic conditions and acute infectious diseases.

PATHOGENESIS (TABLES II AND III)

The apparent port of infectious entry was noted in approximately 40 per cent. of the Iowa series, in which topical infections predominated. The efficient treatment and eradication of infection constitutes an important prophylactic measure. Organisms were found in the vertebral marrow by Fränkel even after the primary focus had healed. This observation elucidates the intervals which were noted in many cases between the port of entry and the clinical manifestations of the disease. In some cases, the relation of a focal infection to the spinal disease is obvious or it may be incidental. In many instances, this could be demonstrated. The relationship between intrathoracic infectious diseases and dorsal spondylitis is obscure in some cases. Such foci may occur simultaneously or become directly involved by extension from one or the other lesion. Careful clinical, bacteriological, and pathological studies are often necessary to establish the facts in the individual case.

Spinal lesions may be classified as direct and hematogenous. Direct

TABLE II

APPARENT PATHOGENESIS (IOWA SERIES ONLY)

Type of Infection	No. of Cases	Total
Topical infection *	12	
Pneumonia	5	
Mastoiditis	2	
Prostatic abcess	1	
Puerperal sepsis	1	
Thrombophlebitis	1	
Sore throat	1	
	—	23

* The topical infections were as follows: boils, 6; felon, 2; cellulitis (face), 1; carbuncle, 2; sties, 1. There was a history of trauma in eight cases.

infections occur postoperatively, through infected decubiti or by extension from a neighboring suppurative focus. The hematogenous forms may arise as initial spinal foci or as metastatic lesions after one or more bony localizations of the disease have already been established. In this (Iowa) series of fifty-three cases, forty lesions were initially spinal and thirteen were metastatic.

The spine was directly and seriously injured in eight cases. Trauma is recorded in about 30 per cent. of all cases of pyogenic osteomyelitis and its significance must be recognized. The spine, perhaps more than any other structure, is exposed to functional stresses and strains and is particularly subject to degenerative changes which enhance infectious invasions under favorable conditions.

The staphylococcus is the invading organism in the great majority of cases. Secondary local and general invasion is not uncommon. Because of the serious nature of the pathological anatomy, the less severe forms of pathogenic and even non-pathogenic organisms may gain a good foothold and cause extensive destruction. The blood cultures are often positive during the bacteriemic phases of the disease.

TABLE III

PATHOGENETIC CLASSIFICATION

	Iowa Series	Questionnaire Series	Total
Spinal Lesion:			
Direct	7	2	9
Hematogenous	53	40	93
Infectious Agent:			
Staphylococcus	29	26	55
Streptococcus	6	4	10
Mixed	5	3	8
Positive blood culture	6	7	13

TABLE IV

PATHOLOGICAL ANATOMY

Series	Involvement of Vertebra	Cervical Region	Dorsal Region	Lumbar Region	Sacrum	Coccyx	Total
Questionnaire *	Body	1	6	17	5	2	31
	Posterior process	2	1	3	1		7
	Combined			4			4
Iowa **	Body	4	22	23	3	1	53
	Posterior process		2	4			6
	Combined	1					1
Total		8	31	51	9	3	102

* In the questionnaire series, the posterior foci were as follows: transverse processes, five; spinous process, one; and the lamina, one. More than one segment was involved in only eleven instances (26 per cent.).

** In the Iowa series, the localization was dorsolumbar in four instances and lumbosacral in ten. In the dorsal region, the posterior localizations were in the laminae; in the lumbar region, the foci involved the transverse processes in two cases, the lamina in one case, and the spinous process in one. The great majority of the foci in the vertebral bodies involved two or more segments.

SEGMENTAL DISTRIBUTION AND PATHOLOGICAL ANATOMY (TABLE IV)

Contrary to earlier belief, pyogenic spondylitis is essentially a disease of the vertebral bodies and their contiguous discs, and seems to have a predilection for the lumbar region, although the dorsal portion is almost as well represented in the Iowa series. In the earlier literature, about 40 per cent. of the cases occurred in the posterior portions of the vertebrae. The predilection for the bodies, as noted at present, may be accounted for by the fact that the surgeon is now better able to discriminate between pyogenic spondylitis and tuberculosis, and because the heaviest and largest vertebrae are in the lumbar region. The transverse and spinous processes are more or less rudimentary structures which form lever arms for muscular and ligamentous attachments.

Pyogenic spondylitis is almost always a diffuse lesion. In this series, practically every instance of the disease involved the bodies or the bodies and posterior processes combined. More than one spinal segment is affected as a rule, at least in the later stages of the disease. This is conditional upon the anatomical and architectural continuity of the cancellous structure in the body and posterior portion of the vertebra. This structural continuity is reflected in the horizontal and vertical trabecular systems. The lesions are of irregular size and shape and their limitation is determined by the vascular collateral circulation. Extension to contiguous disc and vertebral body is further aided by the absence of the

FIG. 1

Autopsy specimen showing pyogenic osteomyelitis of the lower lumbar and lumbosacral spine, with late involvement of the sacro-iliac joints. There is complete bony fusion at the lumbosacral junction, and general eburnation. The intervertebral disc between the fourth and fifth lumbar vertebrae is narrowed, while the discs between the second and third and third and fourth lumbar vertebrae show a definite tendency to herniation.

W. M., aged twenty-three years, was admitted in March 1931. Roentgenographic examination revealed a diffuse increased condensation of the entire lumbosacral region and destructive lesions of the sacro-iliac joints. The patient died in September 1932, following a prolonged stormy illness. The pathological diagnosis was: (1) chronic suppurative arthritis of both sacro-iliac joints; (2) pyogenic osteomyelitis of the lumbosacral spine; (3) right psoas abscess; (4) suppurative phlebitis of the left femoral vein; (5) multiple metastatic soft-tissue abscesses; (6) chronic osteomyelitis of the scapula (healed); (7) amyloidosis of liver and spleen; (8) septicaemia. Histologically, the picture was characterized by numerous focal areas of necrosis, active inflammation, and healed foci.

circumferential cartilage plate and the lack of a definite protective subchondral layer of compact bone as seen in normal joints. The nature of the spongy bone and the peculiarities of the blood supply tend to develop a carious form of destructive necrosis. However, small sequestra, composed of the thin outer compact layer and that portion of the body formed by the ossification of the secondary epiphysis, may and do occur. Condensation, proliferation, and bone production are encouraged by the natural sluggishness of the vascular current. Characteristically, direct infections cause an ulcerative surface lesion of the body, whose depth depends upon the nature of the infectious agent and its duration. The type of lesion in the hematogenous forms is variable and may be destructive and ulcerative, solitary, and localized, primarily in the disc alone, in the disc and the contiguous bony structures, or even in the subperiosteal area. The primary focus is practically always in the bone marrow (usually that of the vertebral bodies) or in the disc. Extension of the lesion may occur also by erosion anteriorly under the longitudinal ligament. Occasionally, multiple small foci of different durations are noted throughout the bodies with reactive zones of eburnation surrounding them. Distinct remnants of the cartilage plate may remain for a long time in spite of the destructive elements of the disease. Rapid invasion of the entire spongiosa may occur with subsequent collapse of the vertebra. The limited pathological material and the roentgenographic studies show that the disease may occur primarily in the posterior intervertebral joints or facets. Undoubtedly

TABLE V

COMPLICATIONS

	Iowa Series	Questionnaire Series	Total
Suppuration	43	9	52
Involvement of the central nervous system	10	8	18
Metastases	8	6	14
Mortality	15	10	25
Sinus formation	13	16	29
Vascular involvement	4		4
Constitutional * involvement	9		9
Gibbosity	9		9
Extension	13		13
Decubiti	5		5
Spondylolisthesis **	1		1

* The constitutional complications incidental or related to the disease were: diabetes, one; lues, two; uraemia, two; psychosis, two; and amyloidosis, two.

** Spondylolisthesis was observed in an eight-year-old boy who presented a diffuse lumbosacral lesion with slipping forward of the involved fifth lumbar vertebra on the sacrum. Under a mistaken diagnosis of tuberculosis, a Hibbs fusion was performed, at which time the lamina and processes of the fifth lumbar segment appeared to be sequestrated. Sinuses and a humeral metastasis followed, with subsequent recovery. Spondylolisthesis was apparently due to the destructive process, although congenital malformation cannot be ruled out.

these joints do become secondarily involved, especially in chronic extensive lesions of the lumbosacral region. Less commonly, small localized foci occur in the posterior portions of the vertebrae, which respond favorably to prompt treatment. Collateral changes occur, as they do so frequently in osteomyelitic processes in the long bones. Pyogenic osteomyelitis is characterized by its variable pathological manifestations, and spinal localizations offer no exceptions to this rule except possibly for the early and persistent attempts at regeneration that go hand in hand with even the most rapid destructive elements of the disease. Suppuration occurs in the vast majority of cases.

COMPLICATIONS (TABLE V)

The most common and important complication from the surgical viewpoint is suppuration and abscess formation. The formation of abscesses is perhaps the most striking feature of pyogenic osteomyelitis of the spine. These are characterized (as in tuberculosis) by their great size (from even relatively small bony foci) and tendency to gravitate and migrate from their original sites. They may burrow into adjacent tissue spaces, into the vertebral-body surface, or even into the spinal canal. The latter invasion is facilitated by the relative weakness and insufficiency of the posterior longitudinal ligament and the loose attachment of the annulus lamellosus posteriorly. Anterior extension is most common and is favored in practically all body lesions because the flexor surface of the spine is in relation throughout with the viscera, from which it is separated only by the prevertebral space. The muscular and fascial attachments

FIG. 2-A

Osteomyelitis of the second and third cervical vertebrae with a rather marked retropharyngeal abscess, which caused this patient, aged thirty-three, classical mechanical symptoms of embarrassment to respiration, deglutition, and phonation.

FIG. 2-B

After operation by drainage anterior to the sternomastoid muscle. Excellent recovery.

of the spine form natural cleavage planes for purulent migration. Such migration is most classically illustrated by the more slowly developing tuberculous collections. Those in pyogenic lesions, which may form with amazing rapidity, often perforate these cleavage planes and trace more bizarre routes. They are governed more or less by their segmental level of origin.

The retropharyngeal abscess most often arises from lesions of the upper cervical vertebrae (Fig. 2-A), and may invade the lateral aspect of the neck, perforate the canal, or descend into the posterior mediastinum. One patient reported the sensation of posterior drip long after the lesion had healed clinically. Rarely a retropharyngeal abscess may descend and form a psoas collection. Bulbar compression, incident to the subsequent luxation of the atlas, may occur. Obstruction of deglutition and embarrassment of respiration are the usual symptoms.

In the thoracic region, our interest centers chiefly about the retromediastinal abscess. The intimate connections of the anterior longitudinal ligament with the costovertebral articulation may deflect pus toward the intervertebral and intercostal spaces, localize the abscess, and give rise to typical paravertebral shadows in the roentgenogram. The pleura and pericardium may be perforated.

The most common site of pus in the lumbar region is between the

iliopsoas muscle and its fascia (Fig. 3). Occasionally, the entire psoas muscle is destroyed and displaced by pus. In this connection, it is necessary to emphasize the great clinical importance of isolated occurrences of iliopsoas abscesses and iliopectineal bursitis with no related vertebral pathology. Rupture of the fascia of the psoas muscle or direct perforation of the anterior longitudinal ligament may give rise to the more extensive forms of retroperitoneal abscesses. Not uncommonly, perinephritic collections of pus result from lumbar foci.

The development of pus from the superficial aspects of the sacrum and coccyx results in surface abscesses. Those abscesses which arise from the anterior borders may burrow downward and laterally and simulate the courses taken by other pelvic osteomyelitic foci. Most characteristically, abscesses in the hollow of the lower sacrum and coccyx collect beneath the levator ani muscle and may appear in the subgluteal region, perianally or perirectally. When they originate above the attachment of the levator ani muscle, a subperiosteal abscess arises which may appear as an ischiorectal abscess or laterally above the crest of the ilium or other regions confusing from a diagnostic viewpoint.

FIG. 3

Pyogenic osteomyelitis of the dorsolumbar spine in a female, aged ten years. This roentgenogram illustrates the value of lipiodol injection of sinuses in order to determine the extent of the process as an aid to diagnosis and plan of operative attack. The sinuses were successfully drained by an incision along the anterior iliac crest.

The invasion of the spinal canal and its contents by vertebral osteomyelitis gives rise to the gravest complications of pyogenic spondylitis. (See Table VI.) There were ten instances of spinal-canal complications in the Iowa series, with a mortality of 50 per cent. Most commonly, cord symptoms are due to an extradural abscess which may remain localized or become diffuse. When the dura is perforated, a typical picture of meningitis follows. Our interest was especially aroused by one case of meningitis in a boy, eighteen years of age, with lumbosacral involvement of eight months' duration. Twelve hours after bilateral drainage by the

TABLE VI

ANALYSIS OF COMPLICATIONS DUE TO INVOLVEMENT OF THE CENTRAL NERVOUS SYSTEM

Iowa Series		
Total number of cases		10 (16.6 per cent.)
Males	7 cases	
Females	3 cases	
Segmental focus of vertebral disease:		
Lumbar	5 cases	
Dorsal	4 cases	
Cervical	1 case	
Time of onset of symptoms related to the central nervous system:		
Range—Onset of osteomyelitis to four years afterward		
Average—Six months after onset of osteomyelitis		
Duration of symptoms related to the central nervous system:		
Range—Onset of osteomyelitis to four years		
Average—About nine months		
Symptoms:		
Sensory	5 cases	
Motor	7 cases	
Root pain	1 case	
None	1 case	
Unknown	1 case	
Pathology:		
Meningitis	4 cases	
Infarction of cord	1 case	
Subdural pus	1 case	
Compression	4 cases	
Bacteriology:		
Staphylococcus	3 cases	
Streptococcus	1 case	
Mixed	1 case	
Treatment:		
1. Bone disease:		
Drainage	3 cases	
None	3 cases	
Conservative	4 cases	
2. Spinal canal:		
Aspiration	1 case	
Mortality	5 cases	(50 per cent.)

laminectomy approach, meningitis developed, as proved symptomatically and by repeated cisternal punctures which yielded pus and a cultural growth of staphylococcus aureus. Death seemed inevitable when the patient was discharged, but he returned completely recovered about one year later, at which time even the spinal fluid was normal.

TABLE VII

TABULATION OF RADIATING OR REFERRED PAIN

Iowa Series		
Total number of cases	20	(33 per cent.)
Time of onset:		
Immediate	14 cases	
Delayed	6 cases	
Type:		
Bilateral	3 cases	
Unilateral	16 cases	
Alternating	1 case	
Distribution:		
Sciatic	7 cases	
Lumbar	8 cases	
Occipital	1 case	
Local	2 cases	
Superior gluteal	2 cases	
Segmental localization of disease:		
Lumbar	13 cases	
Dorsal	5 cases	
Sacral	1 case	
Cervical	1 case	

In contradistinction to the slowly developing insidious symptoms of compression due to tuberculosis, pyogenic infection usually strikes with dramatic suddenness. Not uncommonly, the spinal roots become involved usually indirectly by being surrounded by inflammatory tissue which leads to oedema and infiltration, giving rise to radiating pain (Table VII). Compression symptoms are usually focal, but may not be evident. In one instance discovered at autopsy, there had been no neurological symptoms. Sometimes extensive general involvement blots out all local and focal signs, and leads to errors in diagnosis. The cord suffers chiefly through compression and inflammatory oedema. Septic thrombosis of the spinal plexus of veins is frequent and occurred in two instances. Therefore, so called suppurative perimeningitis is usually secondary to a vertebral osteomyelitis and is seldom primary.

The most common vascular complication is thrombosis of the iliac veins which occurred in three cases incident to lumbosacral disease. The most interesting occurrence was that of a mycotic aneurysm (Figs. 4-A and 4-B). Extension of the disease is most classically illustrated in the lumbosacral region where sacro-iliac involvement occurred in six instances; in two of these cases the involvement was bilateral. Rupture with extension into the neighboring viscera is not an uncommon complication, particularly in cervical and dorsal foci of the disease.

Gibbosity was noted in only nine instances (15 per cent.). This

complication is not so common as in tuberculosis because rapid extensive bone destruction is infrequent, the disease is often quite rapidly fatal, the recumbent position is quickly assumed by the patient, and the bone-production reactions often occur rapidly. However, there is noted in almost all cases some spinal deviation such as mild scoliosis and loss of the normal physiological curves, due either to limited destructive lesions, or changes in the intervertebral discs, or muscle spasm. There was one instance of spondylolisthesis (Fig. 5).

Spontaneous or postoperative sinus

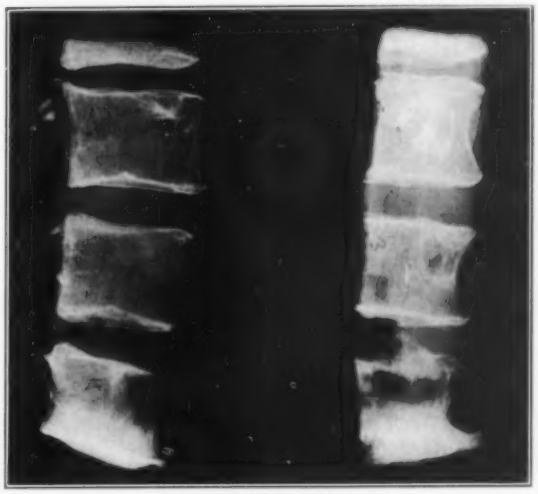


FIG. 4-A

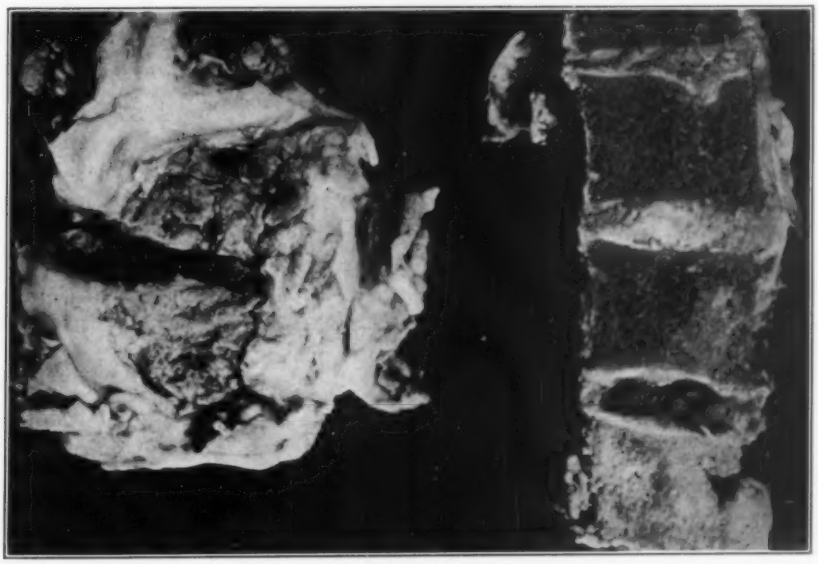


FIG. 4-B

Mycotic aneurysm subsequent to pyogenic osteomyelitis of the third and fourth lumbar vertebrae in a male, aged sixty years, who died on the day of admission to the hospital.

Fig. 4-A: Roentgenogram of the post-mortem specimen, emphasizing the greater erosion on the anterior surfaces of the bodies, due to the aneurysm.

Fig. 4-B: The vertebral specimen and that of the aneurysm. The herniation of the disc between the first and second lumbar vertebrae appears in the roentgenogram, but not the extensive destructive primary disc lesion lower down.

formation is not uncommon and, when observed about the back or in relation to the spine, should always lead one to suspect a spinal focus of the disease. In the low-back region, these sinuses are often multiple and strongly suggestive of chronicity. It is rather surprising that amyloidosis, as proved at autopsy, occurred in only one instance in spite of the chronicity and seriousness of the disease. This was also suspected clinically in one other case in which the patient recovered, although he presented lumbosacral involvement and a huge liver and spleen for almost two years. Recent studies have tended to show that amyloidosis is not a permanent pathological change and that efforts at therapy should not be abandoned when such clinical evidence is present.

FIG. 5

Spondylolisthesis of the lumbosacral spine, associated with or due to an osteomyelitic involvement of the lumbosacral region, in a male, aged eight years. There appears to be a destructive separation of the neural arch at the "isthmus", but a congenital etiology cannot be ruled out.

Bony metastases occurred in eight instances in the Iowa series. In obscure spinal lesions, such complications often lead to a correct diagnosis. More commonly, multiple soft-tissue abscesses occur which seem to help build up the patient's resistance if his general condition is good or fair at the time, but these may be a terminal phase. It is interesting to record that in one instance, in which the spinal localization was in itself a metastatic lesion, the patient made a correct diagnosis immediately, but several weeks elapsed before his medical advisors were convinced.

The mortality in the Iowa series was fifteen cases (25 per cent.) and ten cases (23.8 per cent.) in the questionnaire series,—a substantial reduction from that of the older literature. The prognosis is materially better than is generally appreciated. A good prognosis depends upon a reasonably early diagnosis and adequate treatment which tends to minimize grave complications. It is interesting to note that this disease is essentially a chronic disorder as in its more common long-bone localizations. The shortest duration of the disease among the patients seen in the hospital was two weeks in a case of acute posterior involvement; the longest was twenty-one years in a case of lumbosacral involvement. The range of duration in the group in which the outcome was fatal was between two

TABLE VIII

GENERAL SYMPTOM ANALYSIS

	Iowa Series
Subjective—	
Onset:	
Acute	26 cases
Subacute	15 cases
Insidious	8 cases
Unknown	11 cases
Constitutional reaction:	
Profound	4 cases
Marked	14 cases
Moderate	24 cases
Unknown	18 cases
Spontaneous pain	60 cases
Objective—	
Tenderness	40 cases
Muscle spasm	26 cases
Loss of weight	25 cases
Superficial abscess	17 cases
Parenteral abscess	14 cases
Oedema and infiltration	6 cases
Hip contracture	17 cases

months and ten years (in one case) and averaged (exclusive of the latter) eight and five-tenths months. In the remaining cases, the duration of the disease ranged between seven weeks (coccyx) and twenty-one years (lumbosacral region), and averaged thirty-seven and thirty-five-hundredths months. All in all, deep-seated inaccessible lesions, extensive destruction, and grave complications are the real causes of fatal outcome.

DIAGNOSIS

The most important requisite for clinical diagnosis of pyogenic spondylitis is a knowledge of the disease. An absolute diagnosis can be made only upon bacteriological or microscopic examination of the tissue, or both. Injection of sinuses with an opaque solution and roentgenographic examination will often lend a clue as to the origin of the infection. Bacteriological and microscopic examination of sinus scrapings, with guinea-pig inoculation of the material, is of great aid in the diagnosis. A presumptive diagnosis may be made upon the clinical course of the disease, the roentgenographic examination, the bacteriological and microscopic examinations of associated primary or metastatic lesions, and the blood culture. In the Iowa series, an absolute diagnosis was made in the majority of cases. From the local pathological viewpoint, tuberculosis is the

most difficult disease to differentiate. A discussion of the differential diagnosis involves the following conditions which were mistakenly diagnosed in the Iowa series: tuberculosis, nine cases; appendicitis, four cases; perinephritic abscess, four cases; arthritis of the spine, four cases; pneumonia and empyema, four cases; mediastinal malignancy, three cases; soft-tissue abscess, three cases; meningitis, three cases; sacrolumbar strain, one case; sciatica, one case; mycotic lesion, one case; and ureteral obstruction, one case. In many cases, the diagnosis was made only after an exhaustive study and lengthy observation. A surprising number of cases were diagnosed correctly very early in the course of the disease; some, at autopsy only.

GENERAL SYMPTOMATOLOGY (TABLE VIII)

The onset may be acute, subacute, or insidious. In the very acute cases, the constitutional reaction overshadows the local condition. The apparent discrepancy between the occasional early, small, and even insignificant lesion and the marked constitutional reaction is explained by the severity of the initial primary bacteriemia. Contrary to previous opinion, in the majority of cases the course of the disease becomes subacute or even chronic. *Spontaneous and provoked localized pain is characteristically present in all patients who are mentally alert.* The patient assumes the recumbent position very early and exhibits spinal rigidity due to muscle spasm

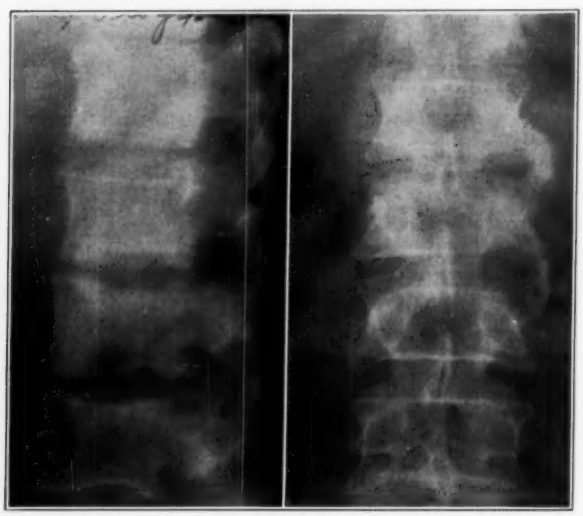


FIG. 6

Late bony bridging in a male, aged thirty-six years, about one year after healing of the operative sinus.

Because of the depth of the lesion, some time may elapse before local signs are definitely demonstrated. Superficial suppurative manifestations appear earlier when the disease originates in the posterior processes. Most commonly there is palpable oedema and infiltration of the back muscles. Posterior superficial fluctuating abscess areas are uncommon in the cervical region where the musculature is dense. In the dorsal and lumbar regions, these abscess areas are not uncommon and are usually at one side of the midline or in the erector spinae sheath. Extensive dissection of the sheath may occur once pus finds its way into this compart-

ment, with attendant destruction of the muscles by pressure atrophy or actual inflammation. Petit's triangle is a favorite site of presentation from lower-back lesions. Occasionally, bilocular superficial abscesses on each side of the midline are noted. Marked tenderness is usually circumscribed; at times, so much so that a minute digital examination must be made in order to detect it. These sites and points of digital-pressure tenderness are remarkable for their tendency to remain localized to the same region in contradistinction to the more shifting sites of tenderness incident to ligamentous strains and sprains, and are almost pathognomonic of pyogenic infection.

Similarly, the spontaneous pain is generally diffuse at the onset and finally becomes well localized to the area involved. The patient assumes various attitudes in an endeavor to obtain relief, but seldom succeeds. Local and general pain is provoked by all movements which produce motion of the spine. In lumbar and low dorsal lesions, meteorism and genito-urinary symptoms are commonly noted. This is probably due to an inflammatory oedema of the prevertebral tissues and the resultant irritation of the sympathetic chain and ganglia. Other symptoms of a visceral nature are governed by the segmental area involved.

FIG. 7

Destructive lesion of several months' duration in the contiguous portions of the second and third lumbar vertebrae in a male, aged sixty years. Death occurred about four months after operation.

The blood cultures are important as an aid in the differential diagnosis, especially with reference to tuberculosis and visceral lesions. The hemoglobin ranged between 55 and 90 per cent. and averaged about 70 per cent. The red blood count usually revealed a moderate degree of anaemia, but in some cases a marked degree was present. The white blood count ranged between normal and 35,000, showing a moderate rise in the subacute and chronic stages of the disease in the majority of cases. The sedimentation time was as low as thirteen minutes and, as an indicator of the general trend of the disease and the degree of operative risk involved, was utilized to good advantage.

ROENTGENOGRAPHIC FINDINGS

The roentgenogram is indispensable in the diagnosis. Pyogenic spondylitis is differentiated from the tuberculous forms chiefly by the increased density, bony bridges, and exostoses which characteristically occur in the former. The soft-tissue paravertebral shadows incident to the attendant oedema may be evident as an early sign and sometimes simulate abscess formation. Abnormalities of the intervertebral spaces, however slight, are important. The trabecular architecture of the affected area becomes obscured in the early stages. The patient must be carefully prepared and the entire spine examined in anteroposterior, lateral, and even oblique views. Many of the most important and earliest roentgenographic changes are noted in the anteroposterior views, particularly static deviations, para-osteal calcifications, localized destructive vertebral-body changes, alterations of the intervertebral spaces, and proliferative changes of all kinds and with varying degrees of bony bridging (Fig. 6). Other changes observed in this series include sequestration, mottling of the vertebrae, and varying degrees of erosion and destructive phenomena. The most destructive phases of the disease in

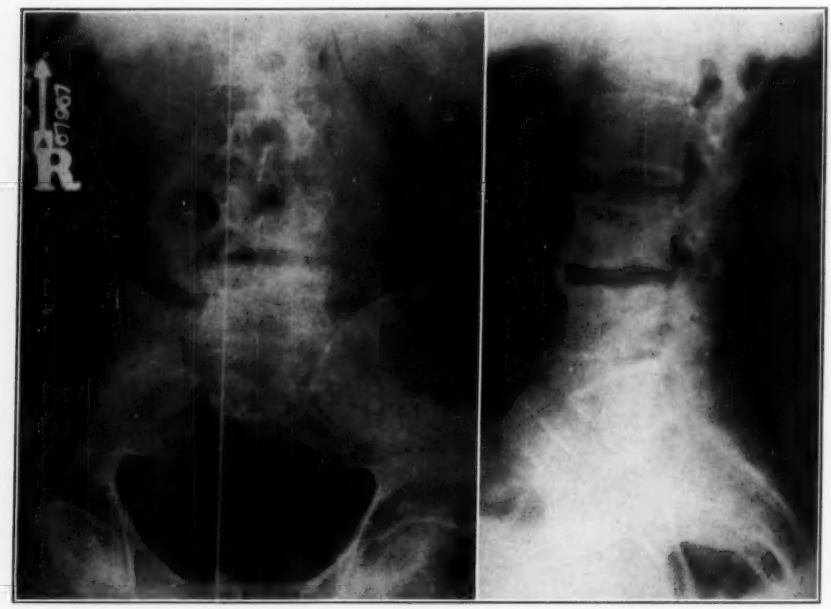


FIG. 8

Roentgenograms showing osteomyelitis of the fourth and fifth lumbar vertebrae in a male, aged forty-two years. The initial infection was that of the brucella organism. One year later, the patient returned with recurrence of back symptoms. Roentgenographic examination revealed a left psoas abscess and bony bridging between the fourth and fifth lumbar vertebrae. This abscess was drained by a posterior incision; at this time, only the staphylococcus, a secondary invader, was recovered. Originally, the focus was in the posterior articular processes and had now extended to the bodies after secondary infection by the usual pyogenic organisms.

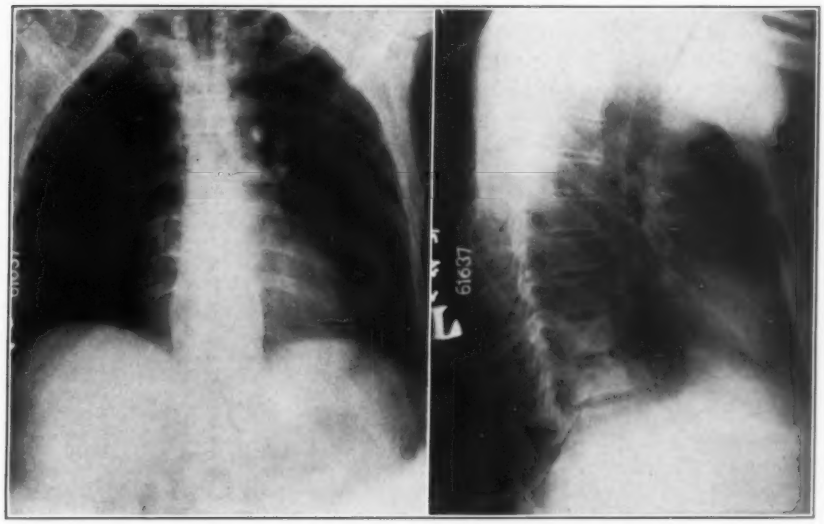


FIG. 9

Pyogenic lesion of eleven months' duration in the lower dorsal vertebrae of a male, aged forty-three years. This case was complicated by empyema. Infiltration shadows show a paravertebral abscess in the soft tissues.

FIG. 10

Extensive lumbosacral and bilateral sacro-iliac osteomyelitis of one year's duration in a male, aged seventeen years. Proliferative changes are negligible. Death ensued, due to local and general complications.

FIG. 11

Localized hypertrophic forms of non-suppurative osteomyelitis in a female, aged twelve years.

the intervertebral disc, in the early stages before contiguous bone has been destroyed, are reflected merely by spacial alterations. The lesion may and does begin in the interarticular joints, and oblique and antero-posterior roentgenograms may reveal pathological deviations here. Because the calcium salts remain and help to localize the lesion in pyogenic bone conditions, atrophic changes do not appear early as a rule. As the

TABLE IX

TREATMENT * AND END RESULTS

	Iowa Series					Questionnaire Series			Total
	Total	Healed	Died	Sinus	Unknown	Total	Healed	Died	
Direct attack	8	5	3	0	0	17	17	0	25
Incision and drainage	27	14	6	5	2	11	5	6	38
Conservative	9	9	0	0	0	9	8	1	18
Laminectomy	0	0	0	0	0	2	1	1	2
No treatment	14	1	5	2	6	2	0	2	16
Spinal fusion	2	0	1	1	0	1	1	0	3
Total	60	29	15	8	8	42	32	10	102

* No division of treatment into the stages of the disease has been attempted because it has no practical therapeutic significance. Direct surgical treatment indicates an attack upon the bony focus, although in most instances the amount of bone removed was insufficient to affect materially the course of the disease. The postural statics of the spine does not permit the ideal removal of the diseased portions entirely. However, radical operations have been done. Adequate drainage is likely to be established when the affected bone is well exposed.

lesion extends, destructive phenomena are evident. Occasionally, there is a complete or wedge-shaped collapse of the vertebral body. The intervertebral discs are often destroyed (Fig. 7).

The most characteristic feature of pyogenic osteomyelitis is the presence of a reactive new bone formation which produces bony bridging and is always present sooner or later in the disease. This bridging and posterior involvement are the chief differential points in ruling out tuberculosis. New bone formation is often very extensive and results in fusion of the vertebrae, even relatively early. In any case of spondylitis which has been studied by serial roentgenograms over a long period of time, the presence of a localized uniform narrowing of the intervertebral spaces with hypertrophic changes about the margins of the vertebrae (Fig. 11), with or without evidence of abscess formation, should suggest the possibility of pyogenic spondylitis, and the history should be investigated and further examination made from that point of view. The most difficult diagnostic problems are presented by the more benign lesions which go on to very little gibbus formation. In acute cases, small focal destructions close to the disc appear and may rapidly involve the disc, with subsequent narrowing. One case showed multiple cystic areas of destruction. What appeared as a diffuse condensation in some low lumbar lesions in the roentgenogram proved at autopsy to be multiple areas of small healed sclerotic foci of the disease. In the case complicated by mycotic aneurysm, the changes in the vertebrae were due to actual destruction by the osteomyelitic process and, in part, by the erosive action of the aneurysmal pulsations on the anterior contiguous surfaces of the vertebral bodies (Fig. 4).

As a rule, abscess formation can be easily demonstrated. The retropharyngeal collection pushes forward the oesophagus and trachea and appears as a smoothly outlined semilunar distension (Fig. 2-A). The shadows cast by purulent localizations are in part due to the associated marked inflammatory oedema of the paravertebral soft tissues. Paravertebral abscesses show up as clearly as do those of tuberculosis (Fig. 9). Iliopsoas abscesses are clearly depicted as bulging iliopsoas-muscle shadows especially when unilateral (Fig. 8). The chief differential diagnostic points in favor of a perinephritic abscess are obscuration of the psoas muscle, deviation of the spine with the convexity toward the lesion, and absence of spinal changes. In a general way, the roentgenographic findings will depend upon the length of the observation period and the underlying pathology. In the Iowa series, roentgenographic studies were made in forty-eight cases.

TREATMENT AND END RESULTS (TABLE IX)

The uncomplicated case of pyogenic spondylitis does not present any particular problem from the surgical viewpoint. Operative intervention is imperative when suppuration is evident. *When in doubt, however, an exploratory incision should be made!* Orr's principles of adequate drainage and adequate rest serve as an excellent guide in the management of this disease. When suppuration is not manifest and the general course of the disease warrants, bed rest on a frame or plaster bed and general hygienic measures are indicated. A simple adequate incision will suffice for most localizations when an abscess is present. When affected bone exists in the posterior processes, it may be identified at the floor of the operative sinus by characteristic roughening and should be removed. The bodies of the vertebrae should not be attacked except for biopsy purposes for obvious anatomical reasons and because of the dangers of subsequent serious hemorrhage. Posterior involvements should be approached by the most direct routes. In the cervical region, the retropharyngeal abscess is best drained by an incision just anterior to the sternocleidomastoid muscle. Blunt dissection through the alar fascia between the cricoid and hyoid bones (neutral zone of Prentiss) is most effective. A bougie or the finger of an assistant should be placed in the pharynx. In the dorsal region, the retromediastinal abscess requires a procedure such as costotransversectomy or a more lateral rib resection.

Lumbar foci may be attacked posteriorly through incisions just at the lateral border of the erector spinae mass. As in all deep-seated foci, there is a tendency toward premature closure of the wound. It may be necessary to cut some of the contiguous muscle layers transversely to prevent this. Drainage through Petit's triangle is often effective even for sacral lesions, which sometimes require partial or total sacro-iliac resection. The coccyx is easily drained directly. When abscesses have gravitated into the pelvis—usually into the iliopsoas sheath—they can be evacuated by an incision along the iliac crest by an extraperitoneal approach. Except

in cases of posterior involvement, the laminectomy approach should be avoided in so far as possible because it exposes the canal and intervertebral foramina to extension contamination. Similarly, indiscriminate aspirations and lumbar punctures may result in complications involving the meninges and the cord. A vaselin pack is lightly inserted into the depths and a generous dressing is applied. It is not necessary to suture any part of the wound. The patient remains recumbent until the wound has healed and is then allowed up in a brace or cast.

Complications must be dealt with as they arise. Some of these have been pointed out and their treatment suggested. Laminectomy is certainly indicated when compression symptoms occur, due to extradural collection of pus. Laminectomy is also often indicated in the chronic stages of the disease when compression symptoms persist. In some cases of meningeal complication, drainage of the subdural space or, at least, repeated puncture drainage may be necessary.

The surgical pathology is interesting and often confusing. Rough bone in vertebral-body involvement is not easily palpable at operation, due to the contiguous oedema of the paravertebral soft structures. Sometimes the abscess is not located, but copious drainage ensues postoperatively if the wound is properly left open. During operative dissection, the oedema of the soft tissues offers an excellent guide to the surgeon and confirms the diagnosis of deep-seated inflammation. Sequestra not uncommonly find their way to the surface during convalescence.

In the Iowa series, spinal fusion was performed under the mistaken diagnosis of tuberculosis. This procedure has been recommended, however, in selected cases of pyogenic spondylitis, but would seem unnecessary in view of the tendency to spontaneous fusion.

In the ten cases in which death occurred in the questionnaire series, the localization of the lesion was: lumbar body, eight cases; dorsal body, one case; and dorsal arch, one case. There were five extensive multiple segmental foci, and other foci of the disease were present in five cases. Seven patients had positive blood cultures. Two cases were complicated by meningitis and one by puerperal sepsis.

In the fifteen cases with a fatal termination in the Iowa series, the localization of the lesion was: cervical body, three cases; dorsal body, four cases; lumbar body, seven cases; and sacral body, one case. All except two of the patients were adults. More than one segment was involved in all of these cases, and the disease was chronic in the majority of cases. One or both sacro-iliac joints and the sacrum were involved in practically every case in the lower lumbar group. Other factors contributing to a fatal outcome were: bacteriemia and sepsis, eleven cases; amyloidosis, one case; involvement of the central nervous system, five cases; mycotic aneurysm, one case; obstruction to the upper respiratory system, three cases; visceral complications, ten cases; thrombosis of the pelvic veins, four cases; and the presence of other foci of the disease in four cases.

SUMMARY AND CONCLUSIONS

More discriminating diagnoses have resulted in a surprising increase in the prevalence of pyogenic osteomyelitis of the spine. The large series observed at the University Hospitals, Iowa City, may be partially accounted for by the rural environment from which most of these patients came, it being generally stated that pyogenic bone infection is most common in such districts. Almost 1 per cent. of all cases hospitalized in these Clinics is due to some form of pyogenic osteomyelitis. There is no evidence to show that pyogenic bone infections in general are gradually diminishing or becoming more benign in this country, as was recently observed by a British writer in his clinic groups.

The diagnosis of pyogenic spondylitis can be made reasonably early if the disease is considered at all. In fact, a knowledge of the disease is the primary factor in the diagnosis. Clinically, there occur acute, subacute, and chronic forms which are not conditional upon the extent of the lesion, but upon the associated bacteriemia and other complications,—particularly the rapidity with which suppuration and abscess formation ensue. The disease is common in adults, although it predominates in the second and most active decade of life. Any part of the vertebral system may be affected, but essentially the disease attacks the bodies of the vertebrae sooner or later, especially if prompt adequate treatment has not been instituted.

The mortality is still too high. It may be axiomatically stated that operative intervention is imperative, as soon as the diagnosis is made with a reasonable degree of certainty, when suppuration is present or suspected in the acute or chronic stages of the disease. The extent of the operation is necessarily limited by the operative risk and the important static function of the spine. The secondary purulent infiltrations must continue to demand our primary surgical considerations. The adequate evacuation and continued drainage of such collections offer great difficulties, and, in general, can best be accomplished by observing Orr's principles. It is an impressive lesson to observe at autopsy the presence of huge pelvic and psoas abscesses after one has thought that the local situation had been adequately taken care of. On the other hand, there are several patients in this series who, following a prolonged period of suffering and discouragement, are well only because of a persistent repeated attack upon the disease. The lumbosacral lesions are particularly difficult to evaluate clinically, especially after one or more of the sacro-iliac joints have become involved by extension (Fig. 10). The primary spinal focus requires the first attention of the surgeon, and any pelvic purulent collection or infiltration should be attacked from every surface possible in order to bring about its successful evacuation and continuous drainage.

No other location reveals so clearly as the spine that we are dealing primarily with a septicaemia in the acute stages of pyogenic osteomyelitis. The local skeletal manifestations of the disease are of secondary importance until suppuration has occurred. Patients who die in the early

acute stages do so because of the intense general sepsis. It is fortunate that, in dealing with spinal foci, we need not concern ourselves with the old debate relative to the early attack upon the bony focus in acute pyogenic bone infection. In treating these lesions, the rule of adequate drainage and rest, as soon as the diagnosis is made, should be followed until further knowledge about the relationship between the port of infectious entry, the septicaemia, and the local condition contra-indicates such measures.

The writer wishes to express his appreciation to the members of the profession who were kind enough to fill out and return the questionnaires on this subject.

SACRARTHROGENETIC TELALGIA

II. A Study of Sacral Mobility

BY HORACE C. PITKIN, M.D., AND HOMER C. PHEASANT, B.S., A.B.,
SAN FRANCISCO, CALIFORNIA

This article is the second of a series of five *. It is based upon additional analyses of the 506 records used in the first article and upon the records of 144 normal male students whom we studied as controls during their routine physical examinations for entrance to the University of California. Its scope is limited to a study of the mobility of the upper sacral joints, and its purpose is to show that sacro-iliac mobility is demonstrable *in vivo*, as well as in autopsy material.

In reviewing the literature, we have encountered very little difference of opinion in regard to the mobility of the sacrolumbar articulation. The sacrolumbar zygapophyses may resemble those between the adjacent dorsal vertebrae, or they may vary through 90 degrees of revolution [6] until they resemble those between the lumbar vertebrae. The type and extent of sacrolumbar motion must vary with the shape of the articular facets, but we have not found any author who doubts that the normal articulation is movable. Abnormal mobility may cause strain—that is, pathological tension—in the extra-articular sacrolumbar ligaments. In the first article of this series [11], we showed that such tension causes sacrarthrogenetic telalgia.

Despite arguments to the contrary, the normal sacro-iliac articulation is a diarthrosis. This fact has been established beyond all possibility of informed doubt by the anatomical and pathological studies of Meyer, Klein, Goldthwait and Osgood, Albee, Derry, Brooke, Sashin, and others. These authors have shown that the normal sacrum takes part in anteroposterior (flexion and extension) movements of the spine and that its average mobility in the cadaver is 4 degrees. Clinical records of sacro-iliac mobility are less easy to find. A few surgeons, like Ryerson, have demonstrated sacro-iliac mobility by manipulating these joints during surgical exposure. Chamberlain and others have determined sacro-iliac mobility by roentgenographic measurements of vertical mobility at the symphysis pubis, but these have been studies of abnormal joints, and we have not found in the literature any clinical measure of normal sacro-iliac motion. It is not difficult to demonstrate anteroposterior motion of the sacrum in two lateral roentgenograms taken with the subject recumbent and with the spine in the positions of acute flexion and hyperextension,

* Of the other four articles, one has been published under the same title [11]; the remaining three are now in preparation and deal with the following phases of the subject:

III. Alternating Scoliosis;
IV. Diagnosis;
V. Treatment.

but this method is not suitable for rapid examinations of large groups of normal subjects.

The axis of normal sacral motion usually is described as a line that parallels the plane of the base of the sacrum and passes through the body of the second sacral vertebra in the transverse plane of the trunk [7]. Such a line crosses each sacro-iliac joint among the interosseous ligaments close to the sacral tuberosity, and lies at the approximate center of the circle that would be formed by continuing the rough arc of the upper two-thirds of the auriculate articular cartilage (Fig. 1). Movements of the sacrum about this transverse axis are analogous to flexion and extension of the spine.

FIG. 1

Lateral view of the sacrum.

Despite the fact that the sacrum is a part of the vertebral column and, therefore, might be expected to take part in rotatory and lateral bending movements of the spine, we have not found any author who describes these types of sacral motion. The shapes of the sacro-iliac joints and their rough interlocking surfaces seem to deny the sacrum any movement about its longitudinal (rotation) or anteroposterior (lateral bending) axes.

In the presence of an intact symphysis pubis, all motions of the innominate bones about the transverse axis of the sacrum, or about the transverse axes of the hip joints, must be paired motions. Antagonistic

motions of this type would rupture the symphysis and are possible only when the symphysis is relaxed or torn. When the weight of the body is borne upon the lower extremities, the paired movements of the innominate bones are flexion and extension about the hip joints. In these movements the sacrum takes little part, since the weight of the trunk, acting through the lordotic lumbar spine, holds it almost continually in a position of flexion *. Movements of the pelvis, other than flexion and extension about the hip joints, are associated with unpaired, antagonistic motions of the innominate bones about a transverse axis that passes through the center of the symphysis pubis. This axis lies at the approximate center of the circle that would be formed by continuing the rough arc of the lower two-thirds of the auriculate cartilage (Figs. 1 and 2). We have checked this type of iliac motion by measurement of antero-posterior and lateral roentgenograms taken with the subjects in the standing position, but we have devised a much more convenient method of measuring it by means of an *inclinometer*.

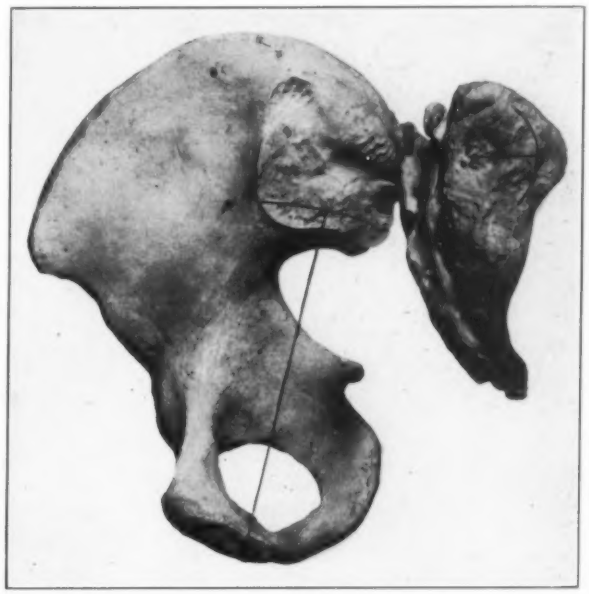


FIG. 2

The centers of sacro-iliac motion.

This instrument (Figs. 3 and 4) is made from a carpenter's calipers to which ball points, a small pendulum, and the scale of a transparent protractor have been fitted. The rod, upon which the protractor and pendulum are mounted, slides through the friction post and continually bisects the space between the arms of the calipers. Thus, the plane of the surface of the protractor always is parallel to a line that connects the tips of the calipers. The examiner applies one tip of the

* Six muscles act directly upon the sacrum. All others must act through the media of the spine and innominate bones. The erector spinae, the multifidus spinae, and the iliacus act as flexors. The gluteus maximus, the piriformis, and the coccygeus act as extensors. None of these muscles arises from the sacrum alone, but each takes an additional and usually a more extensive origin from the contiguous ilium. Only the gluteus maximus has sufficient strength or leverage to overcome the weight of the trunk and to cause the sacrum to extend. Its leverage is increased by flexion of the hips. Its power to act upon the sacrum alone is enhanced enormously by contraction of the flexors of the hips, since these muscles simultaneously immobilize both its iliac origin and its femoral insertion.

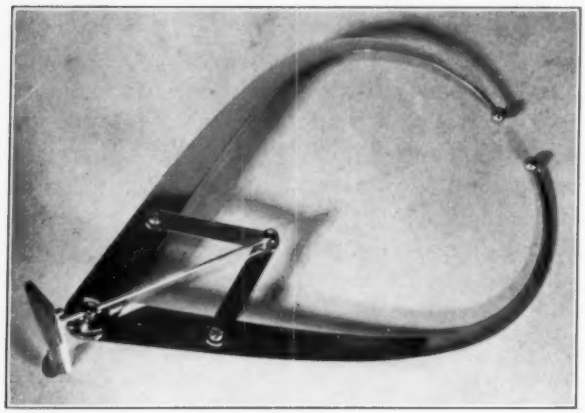


FIG. 3
Inclinometer.

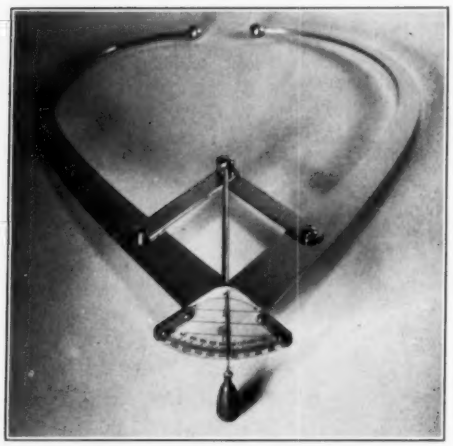


FIG. 4
Inclinometer.

calipers to the anterior-superior spine of one of the subject's ilia; he applies the other tip to the posterior-superior spine of the same ilium; and, finally, he brings the closed end of the calipers to a position such that the pendulum hangs free in the narrow space between the protractor and its back plate. In this position, the plane of the protractor is perpendicular to the plane of the floor, and the examiner may compute the "angle of inclination" of that ilium from the scale of the protractor.

The "angle of inclination" may be defined as the angle formed between the plane of the floor and the projection of a straight line that passes through the posterior-superior and anterior-superior spines of an iliac bone, when the subject is in the standing position. This angle increases with flexion at the hips and decreases with extension. In our series of 144 normal male college freshmen, the average angles of inclination in normal stance were: left, 9.5 degrees; right, 8.2 degrees; average, 8.8 degrees *. In the presence of an intact symphysis pubis, unpaired or antagonistic movements of the ilia must cause a change in the relation of the angles of inclination.

A concrete example of this type of motion is found in the test that we used in the examination of our group of students. Measurements were taken of the angles of inclination of the ilia in three positions. The examiner first requested each subject to place his right foot upon a block of wood, one and one-half inches in height, and then asked him to extend

* The average angles of inclination in our series of cases that showed sacrarthrogenetic telalgia were: left, 7.6 degrees; right, 9.6 degrees; average, 8.6 degrees. The relative positions of the ilia are reversed.

both knees. The latter instruction prevented compensation by flexion of the right knee. Examination of the subjects in this position disclosed the following changes in the relations of the skeleton:

1. The right acetabulum was raised,—that is, the pelvis was tilted toward the left.

2. The pelvis as a whole was shifted toward the right in relation to a point midway between the heels. This caused adduction and relative shortening of the long right leg and abduction and relative lengthening of the short left leg.

3. The left innominate bone was rotated sharply forward about the transverse axis of the symphysis. This caused an increase in the angle of inclination on the left and a tendency toward a further relative lengthening of the short left leg by elevation of the left sacro-iliac joint.

4. The right innominate bone tended to be rotated backward about the transverse axis of the symphysis pubis.

5. The rotation of the innominate bones, the abduction of the left hip, and the adduction of the right hip were not sufficient to correct the tilt of the pelvis toward the left. Thus the lumbar spine showed a scoliosis that was convex toward the left.

6. The lumbar lordosis usually was increased.

7. The vertebral bodies rotated toward the right side,—that is, toward the concavity of the scoliosis *.

8. The trunk, as a whole, tended to list toward the right. The lateral pelvic shift frequently corrected this tendency and sometimes overcorrected it.

9. The completed picture was that of the so called "functional scoliosis" [2].

Having noted the angles of inclination of the ilia in this position, the examiner next took corresponding measurements when the subject had both feet on the floor and, finally, when the subject's left foot alone was elevated upon the block. In this group of normal males, the average total antagonistic mobility of the two ilia was found to be 11 degrees; the greatest total antagonistic mobility was 19 degrees, and the smallest was 3 degrees.

The extra-articular, posterior, sacro-iliac, and sacro-ischial ligaments spread fanwise laterally from the crista sacralis lateralis and forward to their insertions (Fig. 5). The sacro-iliac ligaments oppose sacral hyperextension; the sacro-ischial ligaments oppose sacral hyperflexion. Conversely, in the case of unilateral iliac motion about the transverse axis of the symphysis, the sacro-iliac ligaments on that side

* This spinal rotation is due in part to the forward inclination of the sacrum and occurs even when both sacro-iliac joints are solidly ankylosed. If the sacrum were vertical, all of the pelvic tilt would be transmitted to the last lumbar vertebra as lateral bending toward the side of the shorter leg. Because the sacrum normally is inclined forward at an angle of 60 degrees with relation to the horizon, only two-thirds of the pelvic tilt is transmitted to the last lumbar vertebra as lateral bending; one-third of the tilt is transmitted as rotation of the body of the last lumbar vertebra toward the side of the longer leg.

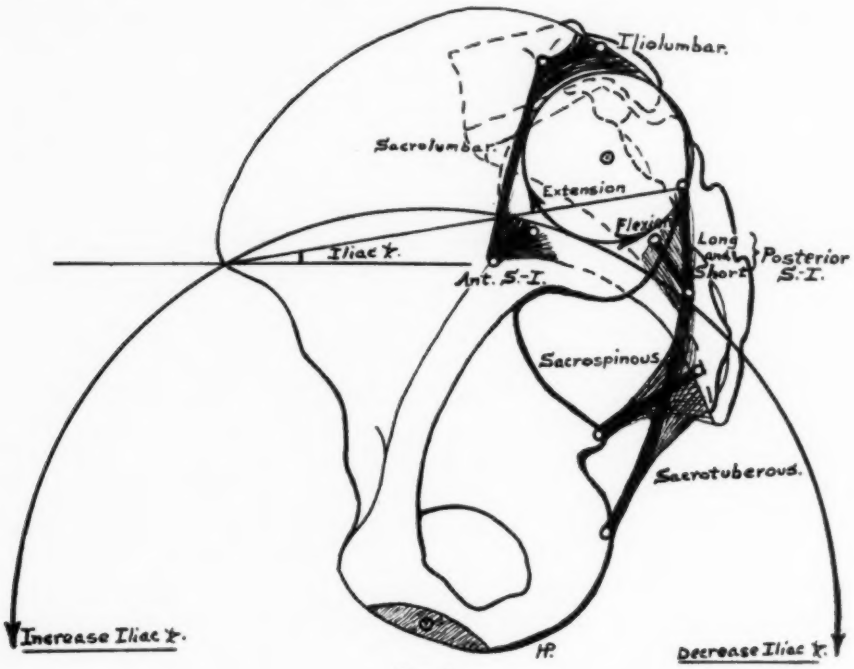


FIG. 5

The extra-articular ligaments of the upper sacral joints.

immediately oppose any attempt to increase the angle of inclination, and the sacro-ischial ligaments immediately oppose a decrease. However, flexion of the sacrum will relax the sacro-iliac ligaments and allow the ilium to rotate forward; extension of the sacrum will relax the sacro-ischial ligaments and allow the ilium to rotate backward. When antagonistic mobility of the two ilia occurs, it thus creates a need for flexion of the sacrum on the side of increasing iliac inclination, and a need for extension of the sacrum on the decreasing side. The sacrum obviously cannot flex and extend simultaneously; it can do only one of these acts, and the weight of the trunk tends to hold it in flexion. Thus, as we have noted in the summary of our examinations of normal males, the ilium that is being rotated forward usually shows a greater excursion than the one that is being rotated backward, and the increased lumbar lordosis reflects the increased flexion of the sacrum.

When an ilium rotates forward about the symphysis pubis as a center, its articular surface, which is slightly behind the center of motion, travels on a rising arc and is carried somewhat upward, as well as forward. Similarly, rotation of the ilium backward causes the articular surface to be translated backward and downward. When antagonistic iliac mobility occurs, the sacrum cannot remain suspended in mid-air, but is forced by gravity to follow any *downward* or *forward* motion of the ilia. Therefore, the articular surface of the sacrum, on the side of the ilium that is rotating

forward, accompanies the articular surface of that ilium in its *forward* and upward movements. The opposite side of the sacrum, in a like manner, accompanies the ilium that tends to rotate backward and *downward*. Thus, the sacrum is caused to bend laterally and to rotate away from the side on which the angle of inclination is increasing. The antagonistic movements of the ilia and the associated movements of the sacrum can be demonstrated quite easily by measurements of roentgenograms, and we have checked our inclinometric figures by this method.

From the foregoing, it is apparent that we must divide sacral mobility into two types:

1. Flexion and extension, in which the sacrum is the moving member and the ilia are fixed.

2. Lateral bending and rotation, in which the ilia are the moving members and the sacrum follows passively.

It should be emphasized that *lateral bending and rotation normally do not occur alone, but as correlated movements*, and that in this respect the sacrum does not differ from the rest of the presacral vertebrae, perhaps excepting the atlas and axis. We have found, by inclinometric and other measurements, that this second type of sacro-iliac motion regularly accompanies all lateral bending and rotatory movements of the trunk (Table I). Because the volitional element is greater in these movements than in the reflex compensation for a lengthened leg, we have not used them for routine tests *.

The problem of measuring separately the mobility of either sacro-iliac joint, when both joints are movable, has proved to be an insoluble one to date. In cases of bilateral sacro-iliac ankylosis, the measurements of iliac mobility regularly have shown less than 2.0 degrees of total antagonism (which establishes the maximum error inherent in this method). In cases of unilateral sacro-iliac ankylosis, antagonistic mobility of the ilia has been found to be identical on the two sides, or to have differed by less than 2.0 degrees. In our group of normal males, the average antagonistic mobility of the left ilium was 4.8 degrees, while that of the right

* The relation of the dominant hand and eye to iliac mobility is interesting and perhaps important. When we made our measurements of iliac mobility in the group of normal students, we also made records of their handedness and eyedness by Quinan's method [12] and discovered the following facts:

1. The dominant eye, primarily, and the dominant hand, secondarily, are associated with a decrease in the iliac inclination on the same side in normal stance.
2. Unilateral double dominance is associated with:
   a. The largest difference between the two angles of inclination in normal stance, the doubly dominant side tending to show the smaller angle;
   b. The largest excursion of one ilium, usually the one on the doubly dominant side when that side is lowered;
   c. The largest net change in the inclination of the pelvis as a whole, since the less mobile ilium frequently follows rather than opposes the motion of the more mobile one.
3. Right-eyedness is associated with the largest total antagonistic mobility of the two ilia.
4. Left-handedness is associated with the largest discrepancy between the individual excursions of the two ilia.
5. The largest net change in the inclination of the pelvis as a whole is associated with the smallest total antagonistic mobility of the two ilia, and *vice versa*.

TABLE I

NORMAL MECHANICS OF THE PELVIS AND SPINE IN THE ERECT POSITION
(FLEXION AND EXTENSION ARE NOT INCLUDED BECAUSE THEY DO NOT CAUSE TORSION OF THE PELVIS)

Effect Upon	Short Right Leg, or Lift under Left Foot	Short Left Leg, or Lift under Right Foot	Bending of Trunk to Left, and Shifting of Pelvis to Right	Bending of Trunk to Right, and Shifting of Pelvis to Left	Rotation of Trunk to Left, and of Pelvis to Right	Rotation of Trunk to Right, and of Pelvis to Left
Left Acetabulum	Up	None	Up	Down	(Down)	(Up)
Right Acetabulum	None	Up	Down	Up	(Up)	(Down)
Pelvic Tilt	Right	Left	Right	Left	Left	Right
Pelvic Shift	Left	Right	Right	Left	(Left)	(Right)
Left Iliac Inclination	(Decreased)	Increased	Increased	(Decreased)	(Decreased)	Increased
Right Iliac Inclination	Increased	(Decreased)	(Decreased)	Increased	Increased	(Decreased)
Sacral Motion—Longitudinal Axis	Left rotation	Right rotation	Right rotation	Left rotation	Left rotation	Right rotation
Sacral Motion—Anteroposterior Axis	Left lateral bend	Right lateral bend	Right lateral bend	Left lateral bend	Left lateral bend	Right lateral bend
Lumbar Curve Convexity	Right	Left	Right	Left	Left	Right
Rotation of Pelvis—Longitudinal Axis	Left	Right	Right	Left	(Right)	(Left)
Dorsal Curve Convexity	Right	Left	Right	Left	Right	Left
Rotation of Shoulder Girdle—Longitudinal Axis	Left	Right	Right	Left	Left	Right
List	(Left)	(Right)	Left	Right	Right	Left

The parentheses in the above columns indicate weak actions that always are present, but that may be neutralized or overcome by the dominant actions.

ilium was 6.2 degrees. This represents a total antagonistic mobility of 11.0 degrees. In our group of cases that showed sacrarthrogenetic telalgia, the antagonistic mobility of the ilia was found to be increased; its average measurement was 7.0 degrees for the left ilium, 7.6 degrees for the right ilium, and the total was 14.6 degrees *. A comparison of the two groups shows that in the group with sacrarthrogenetic telalgia the average mobility of the left ilium was increased by 2.2 degrees, or 46.0 per cent.; that of the right ilium was increased by 1.4 degrees, or 23.0 per cent.; and the average total mobility was increased by 3.6 degrees, or 33.0 per cent. If one will imagine the effect of an increase of 33.0 per cent. in the mobility of any joint with which he is completely familiar, he will recognize the possibilities of strain that such abnormal mobility entails.

The ilium on the side of maximum pain may show an increased mobility or a decreased mobility, but, when we consider that in this series the average increase in mobility of the left ilium was 23.0 per cent. greater than that of the right, the following figures become significant. Tenderness of the posterior sacro-iliac ligaments was 14.0 per cent. more frequent on the left side than on the right. The patients complained of telalgia originating in the left sacro-iliac joint 17.0 per cent. more often than in the right. Prone-knee flexion [10] was more limited on the left side 37.0 per cent. more often than on the right. Supine straight-leg raising was more limited on the left side 41.0 per cent. more often than on the right.

In the first article of this series, we showed that sacrarthrogenetic telalgia in the lower extremities is caused by pathological changes in the tension of the extra-articular ligaments of the upper sacral joints. At that time we omitted all consideration of sacro-iliac mobility. The parallelism between the incidence of sacrarthrogenetic telalgia, abnormal mobility of the ilia, tenderness of the sacro-iliac ligaments, the patient's opinion of the source of his pain, and the results of those tests which tend to increase the tension of the sacro-iliac ligaments is too striking to be fortuitous. We feel that abnormal sacro-iliac mobility is not only a regular concomitant, but also a potent cause of the abnormal ligamentous tension that produces sacrarthrogenetic telalgia.

CONCLUSIONS

1. Sacro-iliac mobility can be demonstrated *in vivo* by measuring the movements of the ilia.

2. In the standing position, all motions of the trunk, with the exception of flexion and extension, normally are associated with unpaired, antagonistic movements of the ilia about a transverse axis that passes through the center of the symphysis pubis.

* Only the males were considered in computing this average, in order to make the figures more accurately comparable. The average age of the individuals in this group was considerably greater than in the normal group, so that, all other factors being equal, the mobility in the normal group should have been the greater [3].

3. Rotation and lateral bending of the sacrum normally do not occur alone, but as correlated motions that are coincidental to antagonistic movements of the ilia.

4. The positions of the ilia in normal stance, as well as their relative mobility, are affected by the dominant eye and hand.

5. The average antagonistic mobility of the male ilia is found to be increased 33.0 per cent. above normal in those subjects who complain of sacrarthrogenetic telalgia.

6. Abnormal sacro-iliac mobility is a potent cause of the abnormal ligamentous tension that produces sacrarthrogenetic telalgia.

REFERENCES

1. Albee, F. H.: A Study of the Anatomy and the Clinical Importance of the Sacro-Iliac Joint. J. Am. Med. Assn., LIII, 1273, 1909.
2. Brewster, A. H.: Nelson Loose-Leaf Living Surgery, III, 165. New York, Thomas Nelson & Sons.
3. Brooke, R.: The Sacro-Iliac Joint. J. Anat., London, LVIII, 299, 1923–1924.
4. Chamberlain, W. E.: The Symphysis Pubis in the Roentgen Examination of the Sacro-Iliac Joint. Am. J. Roentgenol., XXIV, 621, 1930.
5. Derry, D. E.: The Influence of Sex on the Position and Composition of the Human Sacrum. J. Anat. and Physiol., London, XLVI, 184, 1911–1912.
6. Goldthwait, J. E.: The Lumbo-Sacral Articulation. An Explanation of Many Cases of "Lumbago", "Sciatica", and Paraplegia. Boston Med. and Surg. J., CLXIV, 365, 1911.
7. Goldthwait, J. E., and Osgood, R. B.: A Consideration of the Pelvic Articulation from an Anatomical, Pathological and Clinical Standpoint. Boston Med. and Surg. J., CLII, 593, 634; 1905.
8. Klein, G.: Zur Mechanik des Ileosacralgelenkes. Ztschr. f. Geburtsh. u. Gynäkol., XXI, 74, 1891.
9. Meyer, G. H.: Der Mechanismus der Symphysis sacro-iliaca. Arch. f. Anat. u. Physiologie (Leipzig), I, 1, 1878.
10. Pitkin, H. C.: Prone Knee Flexion: In Differential Diagnosis of Low Back Pain. California and West. Med., XXXVIII, 51, 1933.
11. Pitkin, H. C., and Pheasant, H. C.: Sacrarthrogenetic Telalgia. I. A Study of Referred Pain. J. Bone and Joint Surg., XVIII, 111, Jan. 1936.
12. Quinan, Clarence: The Handedness and Eyedness of Speeders and of Reckless Drivers. Arch. Neurol. and Psychiat., XXV, 829, 1931.
13. Ryerson, E. W.: Surgical Treatment of Low Back Disabilities. J. Bone and Joint Surg., XIV, 154, Jan. 1932.
14. Sashin, David: A Critical Analysis of the Anatomy and the Pathological Changes of the Sacro-Iliac Joints. J. Bone and Joint Surg., XII, 891, Oct. 1930.

LUMBOSACRAL FUSION FOR THE RELIEF OF LOW-BACK PAIN

A Report of Thirty-Five Cases

BY HAROLD G. LEE, M.D., BOSTON, MASSACHUSETTS

From the MacAusland Orthopaedic Clinic

The painful low back, orthopaedic in nature, which fails to respond to conservative measures still presents a problem. While operative fusion of the spine has assumed a prominent place in the treatment of these difficult cases, the published reports of spine fixations for this affection are comparatively few, and many attempts have given unsatisfactory results. It is not easy to obtain a solid fixation of the lumbosacral region. The successful fusions in thirty-two of the thirty-five cases that form the basis of this paper were due to the introduction of a larger amount of bone for grafts than is provided for by the usual technique.

From the diagnostic standpoint this report will substantiate the view held by many observers,—namely, that anomalies of the fifth lumbar vertebra or postural variations at the lumbosacral junction are often the underlying factors in the causation of low-back pain. The complete relief that followed fusion of the lumbosacral junction in the series of cases to be reported proved to the writer's satisfaction that the site of pain was localized in this area.

SUMMARY OF CASES

The series of thirty-five cases extended over a period of approximately five years.

Eighteen of the patients were males and seventeen were females. This equal distribution of the affection between the sexes would point to anatomical irregularities as factors in the etiology of back pain.

The ages of the patients at the time of operation ranged from thirteen to sixty-one years. Sixty per cent. were between twenty-one and forty years of age at the time of operation, and, in all but one case, symptoms had been experienced for more than a year before the spine was fused. Eight patients were between thirteen and twenty years of age. It is seen from this age distribution that low-back pain is experienced more commonly during the active years of life.

The back pain was usually associated with pain radiating down one or both thighs, and in many cases there was an area of pain on the outer side of the calf just below the knee joint. The pain in the back was usually experienced at the muscle attachments on the ilium and seemed to radiate over the sacro-iliac region. There were two cases in which the chief complaint was pain referred to the hips, although, as is usual in such cases, when the patients were questioned carefully they admitted having suffered from back pain sometime in the past.

FIG. 1-A

FIG. 1-B

W. B. Anteroposterior and lateral roentgenograms before spine fusion, showing marked blunting of the facets of the fifth lumbar vertebra. Note the horizontal sacrum.

FIG. 2-B

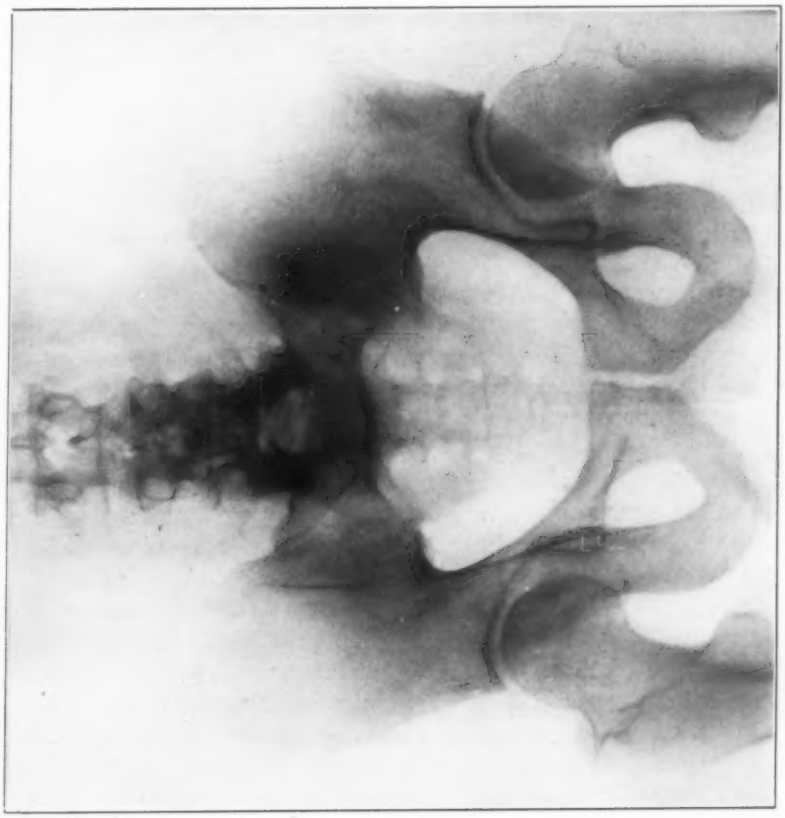


FIG. 2-A

W. B. Postoperative roentgenograms nine months after fusion.

In the majority of cases, the onset of symptoms was ascribed by the patient to a strain incurred either while lifting a heavy object or in falling, and recurrent attacks of disability had been experienced over a period of several years. At some time in the course of treatment, all cases had been diagnosed as sacro-iliac disturbance, and all patients had undergone the customary medical and conservative orthopaedic treatment.

The determination that mechanical derangements and pathological changes existed in the lumbosacral region was made from a study of the roentgenograms. It is unnecessary to review in detail the lumbosacral junction with its numerous anatomical variations and its vulnerability to stress and strain; medical literature contains ample discussions of all phases of the subject. In this particular series of cases, the predominant anatomical defects and variations of the lumbosacral region considered to be potentialities of disturbance were, in the order of relative frequency, as follows:

Slumping of the fifth lumbar vertebra and impingement posteriorly on the sacrum		7 cases
Asymmetrical facets, or variation in the positions of the articular facets		8 cases
Facets asymmetrical in outline	3 cases	
Facets asymmetrical in position	4 cases	
Marked blunting of the facets of the fifth lumbar vertebra (Figs. 1-A and 1-B)	1 case	
Incomplete closure of the posterior neural arch with spondylolisthesis		7 cases
Sacralization		2 cases
Also in combination with asymmetrical facets	1 case	
Also in combination with horizontal sacrum and slumping of the fifth lumbar vertebra	1 case	
Perpendicular sacrum		3 cases
Impingement of spinous processes (Fig. 3)		1 case
		28 cases

These defects were seldom isolated, but existed in combination with various other structural abnormalities. In the first group of cases, there were two in which, in addition to the slumping of the fifth lumbar vertebra, the sacrum was horizontal. In the second group of cases, sacralization or defects of the sacrum accompanied the irregularity of the articular facets.

Spondylolisthesis, in the third group of cases, was associated with lack of bony fusion of the posterior neural arch in the fifth lumbar vertebra on one or both sides. In four of the seven cases, the laminae were freely movable. In one case—that of the thirteen-year-old patient—the laminae were completely separated centrally and were only partly ossified and in two distinct sections (Fig. 4). In all seven cases, the origin of the spondylolisthesis seemed to be definitely congenital. In only one case did injury enter in as a factor, and even in this exceptional case the part that trauma played is questionable as the case was one under litigation. The clinical picture did not differ in any special respect from that of the other groups, except that physical examination revealed the typical lumbar lordosis and

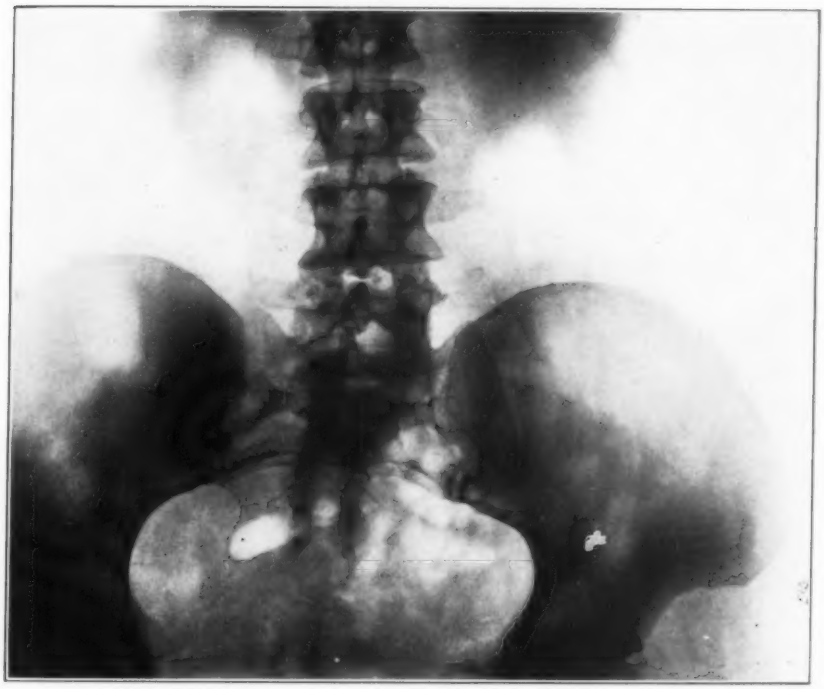


FIG. 3

I. K. Before spine fusion. Note impingement of the spinous processes.

prominent spinous process of the sacrum. The longest duration of symptoms in these cases was six years and the shortest was six months.

In only one of the cases of sacralization had actual fusion of the transverse process of the fifth lumbar vertebra taken place; this was a case of unilateral fusion with marked torsion of the spine toward the sacralized side. Sacralization, whether complete or incomplete, renders the lumbosacral area susceptible to strain. Listing develops, first from a lumbar torsion, to which later is added a compensatory dorsal curve. The advantage of recognizing a sacralization early in life is apparent.

In one case, the roentgenogram showed anomalies of the spinous processes with some fusion of the fourth and fifth lumbar vertebrae, which had already been established by nature. There were also marked arthritic changes between these vertebrae. The patient was a man sixty years of age and he had suffered from pain for over twenty years. Complete relief followed fusion of the lumbosacral region.

When any of the structural changes already described exist in the lumbosacral region, it is easily understood how this junction is thrown open to strain. Sudden trauma, occupational strain, excessive weight, or faulty weight-bearing aggravate the normal strain, with a consequent development of arthritic changes. Muscle spasm sets in to protect the affected area, but, in turn, it creates further strain and faulty weight-

bearing, which lead to the development of additional irritative changes. It is a vicious circle!

Occasionally, a case is seen of a purely mechanical impingement of the fifth lumbar vertebra without arthritic changes. It is noted that patients with such lesions complain of pain while standing, but often, after lying down for a period varying from fifteen minutes to an hour, they secure relief. The mitigation of pain in these cases is in contrast with the continual pain experienced in cases in which irritative arthritic changes have occurred.

In only seven of the thirty-five cases were factors other than congenital abnormalities the apparent causes of the back pain. Arthritis, toxic

FIG. 4

A. G. Preoperative roentgenogram, showing spondylolisthesis in a boy, aged thirteen. The laminae are completely separated posteriorly, are only partly ossified, and are in two distinct sections. The sacrum is horizontal.

FIG. 5-B

FIG. 5-A

A. G. Postoperative roentgenograms, one year after fusion.

in origin, was the causative agent in three cases; the process started low down and spread upward. In three cases, abnormal static conditions, caused by a short leg, resulted in the development of structural curves with accompanying low-back pain. In the one remaining case, a severely marked list, of long-standing and associated with irritative joint changes,

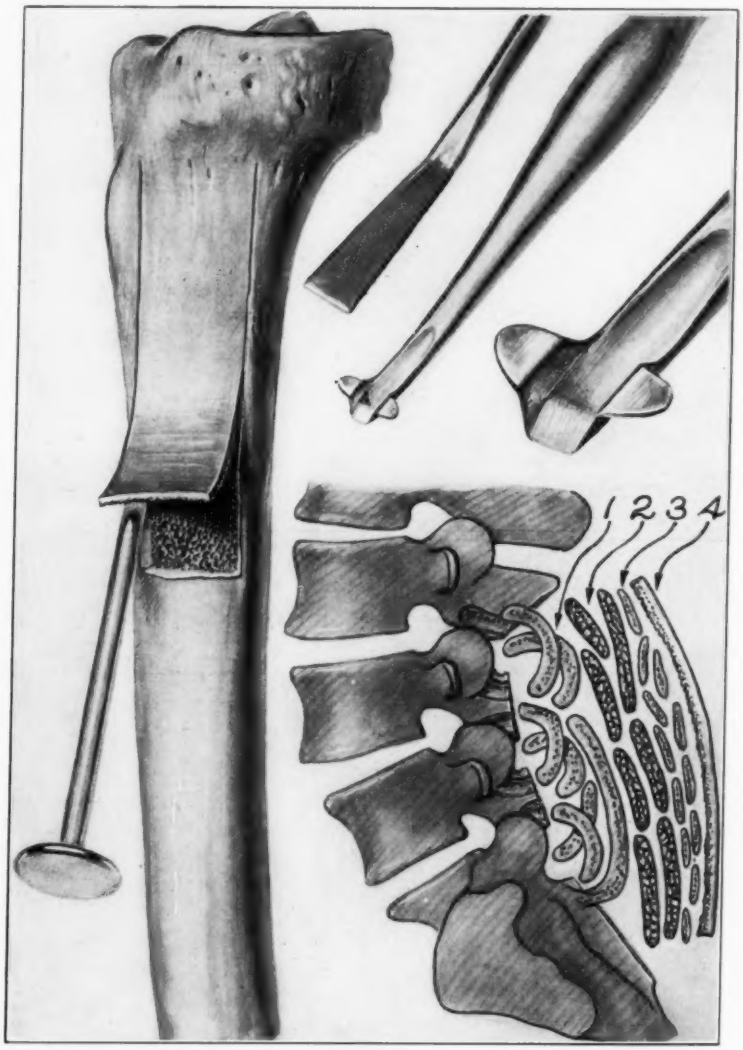


FIG. 6

Spine fusion, showing:
Left: Removal of osteoperiosteal grafts from the tibia.
Upper Right: Special instruments used for turning up grafts from the laminae and sacrum and obtaining cortical chips of bone from the tibia.
Lower Right: The various layers of grafts in place:
1. The grafts turned up from the laminae and sacrum;
2. The cut-up spinous processes;
3. The cortical slivers of bone obtained from the tibia;
4. The broad grafts obtained from the tibia.

had followed trauma.

The explanation of the causation of pain is still being sought. Mitchell, in his excellent article on "The Lumbosacral Junction", described fully the relation between nerve-root distributions and such derangements as spondylolisthesis, slumping of the fifth lumbar vertebra, and an acute lumbosacral junction. In brief, the pain is presumably due to the tension on the nerves produced either by congestion or by stretching. In the case of the nerves of the fifth lumbar vertebra, which are of fair size and have relatively small foramina through which to pass, it is easy for the inflammatory reaction to produce pressure. Because of the tendency of the irregular anatomical structures to twist, it is also possible that torsion causes stretching of the nerves. The fact that many patients obtain relief by lying down would seem to bear out the theory that some mechanical factor, such as is produced by torsion, may disturb the nerves in some cases. Apparently, bony impingement without motion does not enter into the production of pain, for, although deformity is not corrected at the time of operative fusion, the patient obtains relief.

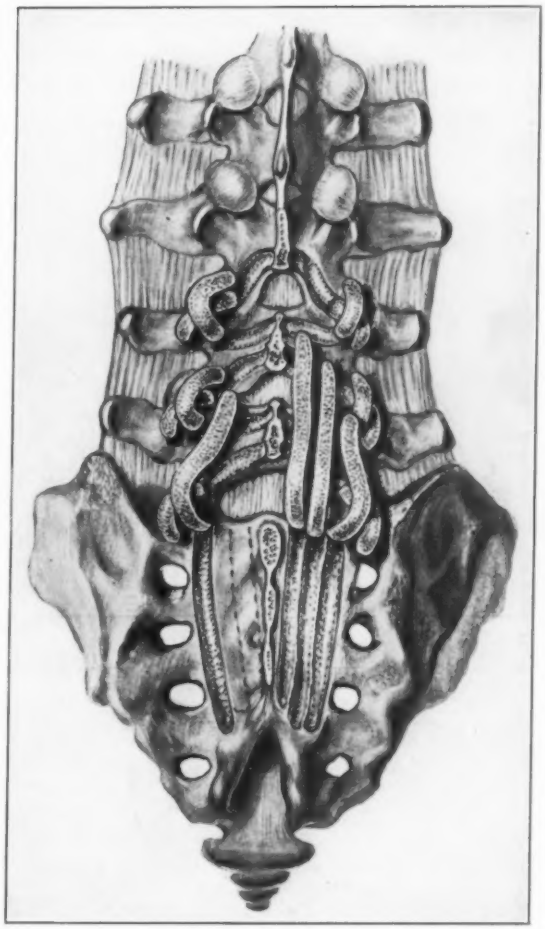


FIG. 7

Spine fusion, showing heavy chip grafts turned up and down from each lamina and overlapped. Grafts are also turned up from the sacrum.

TECHNIQUE OF OPERATION

The patient is prepared for operation in the usual manner. One shoulder is raised on a rest to bring the chest off the operating table, in order not to embarrass respiration.

A curved skin incision is made over the area to be fused, and the line is so placed that it does not lie over the fascial incision, in order to minimize the danger of infection.

The fascia is cut directly over the spinous processes.

The spinous processes of the fourth and fifth lumbar vertebrae and, as a rule, of the third lumbar vertebra, as well as those of the sacrum, are carefully denuded in order to obtain good exposure. A great deal of time need not be used in removing all the ligamentous attachments and tips of the processes. The laminae are thoroughly cleaned as far back as possible.

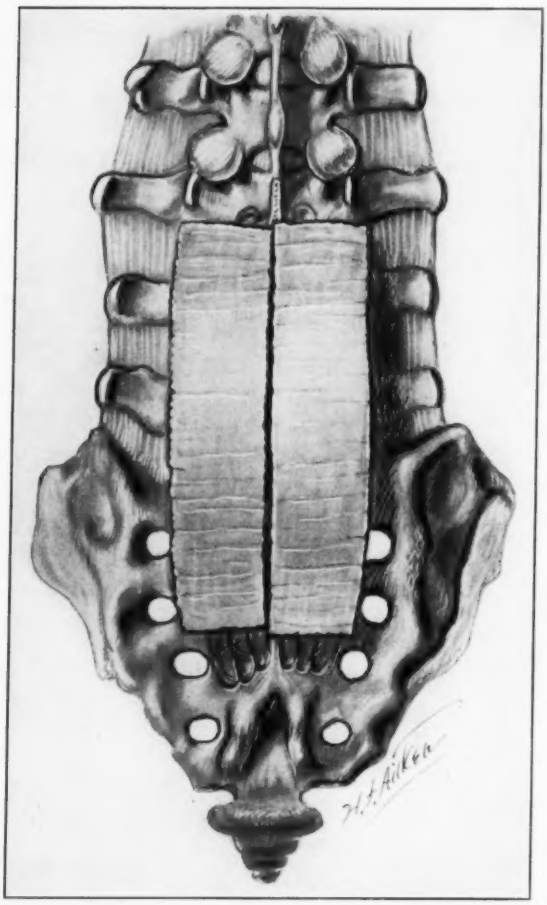


FIG. 8

Spine fusion, showing broad tibial grafts in place.

If the lumbar muscles are heavy, they are cut half an inch from their attachment on the sacrum in order to avoid undue pressure during retraction.

The spinous processes are cut off at their base, removed, and placed in salt solution. Care is taken to cut the third vertebra in a slanting direction to avoid a prominence that would become an area of tenderness.

Heavy chip grafts are turned up and down from each lamina. A special instrument is used for this purpose.

With the same instrument, heavy grafts are turned up from the sacrum. It is to be noted that, when actual slipping forward of the fifth lumbar vertebra has occurred, care must be taken to make the union between the laminae and the sacrum especially secure. If the laminae are mobile and cannot be successfully fused, they should be removed and included in the bridge of bone established at the base of the laminae.

The spinous processes are completely denuded of fascia and, in the case of younger persons, of cartilage attachments. They are then cut into fine pieces and carefully packed over the chipped grafts in the spine bed.

One or both tibiae are opened and osteoperiosteal grafts, together with numerous small slivers of cortical bone, are removed. The cortical

chips are first pressed over the grafts already in place, and then the broad tibial grafts are placed side by side, so that the final layer of grafts is about two inches in width and at least one inch in thickness at the lumbosacral junction. (See Figures 6, 7, and 8.)

The periosteum, muscles, and fascia are sutured over the grafts, and the skin is closed.

Care is taken to leave the wound dry by squeezing out the blood clots. A small sandbag is incorporated into the scultetus bandage to exert pressure on the wound and grafts during the first twenty-four to forty-eight hours. The patient is placed on his face.

After-Care

The patient is recumbent in bed for four weeks. A plaster jacket or pelvic back brace is then applied and is worn for a varying period of time. The patient should be ambulatory six weeks after the operation, and all support should be discarded within six months. The fusion should be solid in three months.

Comment

There was no operative shock in any case. There were no deaths. In one case, the wound became septic, partly as the result of excessive pressure from retractors as evidenced by sloughed muscle.

END RESULTS

At postoperative examination it was found, as a rule, that the patient with litigation pending continued to complain of symptoms longer than did the patient whose case had been uncomplicated. The only postoperative difficulty encountered in these cases has been pain in the coccyx, a symptom that is undoubtedly due to the more erect posture. It is, however, only transitory and disappears as soon as the flexibility above the fusion returns.

Thirty-three of the thirty-five patients were examined after a period ranging from one to five years. In the other two cases fusion had been done only five and six months previous to examination. The following table shows the approximate periods of follow-up:

5 months	1 case
6 months	1 case
1 year	12 cases
1½ years	2 cases
2 years	3 cases
2½ years	3 cases
3 years	3 cases
3½ years	1 case
4 years	5 cases
5 years	4 cases

Excellent results—that is, complete relief from symptoms—have been obtained in twenty-nine cases. Both clinically and by roentgenographic examination, the fusion has been demonstrated to be solid. The

patients have returned to their various occupations: several do heavy work; others are clerking; and one is a superintendent in a hospital. Two patients have borne children, and the deliveries have been normal and without difficulty.

One patient has relief from symptoms, but experiences a peculiar sensation in the back. This was a case in which the graft had to bridge over a defective lamina that was cartilaginous and separated. (The writer now removes such laminae at the time of operation.) The patient is doing heavy work and there is every indication that the final outcome will be satisfactory.

The patient upon whom the spine fusion was performed only six months ago has no symptoms at the present time, and the fixation is solid as evidenced in the roentgenogram. The eventual outcome should be satisfactory. It is likewise expected that the patient who was treated operatively five months ago will obtain an excellent result.

In the three remaining cases, symptoms have persisted after fusion, and the roentgenograms do not show solid fixation.

CONCLUSIONS

From the satisfactory results obtained by operative fusion of the lumbosacral region in a series of thirty-five cases, it would seem that this procedure has a definite place in the treatment of low-back pain, when conservative measures are of no avail and when the roentgenogram demonstrates pathology or structural changes consistent with the clinical findings.

Operative fusion of the spine, to be effective in abolishing back pain, must insure absolute obliteration of all motion at the lumbosacral junction. In cases where fusion of the spine has failed to give relief, the fixation has been found, both clinically and by roentgenographic examination, to be incomplete. By the use of the operative technique described by the writer, elimination of all motion is certain.

In the diagnosis of low-back pain, more attention should be directed to the bony structure in the lumbar region and particularly to the posturally defective back. In the presence of atypical structures, trauma becomes at the most only an aggravating factor in the causation of pain. The significance of defective structures is to be especially considered in the care of industrial injuries.

Our understanding of the structural abnormalities that may underlie back pain now makes it possible to single out the spine that may be a potential source of disturbance. As a result, fusion may be carried out without subjecting the patient to long-drawn-out conservative treatment. Also, from stereoscopic studies of the lumbosacral region, it is possible to classify laborers as to physical fitness for heavy work.

REFERENCE

MITCHELL, G. A. G.: The Lumbosacral Junction. J. Bone and Joint Surg., XVI, 233, Apr. 1934.

A METHOD OF DEALING WITH CHRONIC OSTEOMYELITIS BY SAUCERIZATION FOLLOWED BY SKIN GRAFTING

BY BASIL ARMSTRONG, M.B., B.S. (LONDON), MARGATE, KENT, ENGLAND
Medical Superintendent, Royal Sea-Bathing Hospital for Surgical Tuberculosis, Margate

AND T. FRANCIS JARMAN, M.B., B.S., M.D., BRIDGEND, WALES
Late Assistant Medical Superintendent, Royal Sea-Bathing Hospital, Margate; Assistant Tuberculosis Physician, Welsh National Memorial Association

The problem of applying Thiersch grafts to cavities and recesses has been successfully solved by Esser and Gillies in their plastic work. Esser devised the plan of applying the grafts on a mold of Stent's dental composition which exactly fitted the cavities to be grafted.

The idea was conceived that this method might well be applied in promoting the rapid epithelialization and healing of bone cavities left after radical operative treatment of chronic osteomyelitis. Prior to the adoption of this method some eight years ago, these cavities had been treated by packing with sterile gauze in the ordinary way, and it was noted that the granulations grew much faster from the peripheral parts of the cavities than from their depths, which often resulted in the formation of small deep-lying saccules connected by a narrow track with the superficial surface of the granulation tissue. These saccules were responsible for the persistence of multiple points of discharge on the surface of the granulation tissue and failure of epithelialization at these points.

The method to be described obviates this disadvantage and promotes really rapid epithelialization.

DESCRIPTION OF THE METHOD

First Stage: Saucerization of the Diseased Area

A tourniquet is applied, as this greatly facilitates the operation by improving the field of vision.

An incision is made to expose the area of bone to be dealt with. This incision embraces all sinus-bearing areas in the immediate vicinity, and such areas are excised.

Sufficient bone is then removed to expose the chronic osteomyelitic cavities which may contain sequestra. In the performance of this early step in the operation, either the periosteum should not be reflected at all, prior to the removal of the outer layer of bone with the chisel, or such reflection should be extended no more than is absolutely necessary, as the outer layers of the long bones receive their blood supply from the periosteum and the removal of the latter will result in the sequestration in flakes of the superficial layer of bone along the border of the cavity left after saucerization.

All sequestra are removed and the diseased area of bone is thoroughly eradicated until the cavity so formed is surrounded by relatively smooth and healthy involucrum. In performing this eradication of the diseased areas of bone, it is advantageous, whenever possible, so to shape the cavity that in transverse section it resembles a funnel or saucer with the mouth wider than the floor, and in longitudinal section it has at its proximal or distal extremity, or at both, a considerable overhang formed by the superficial layer of the excavated bone. The recesses thus formed will provide an efficient natural means of retention for the stent mold which is to be applied at a later stage in the treatment.

FIG. 1-A

Cavity requiring only a single stent mold for grafting purposes.

FIG. 1-B

Cavity requiring the insertion of two stent molds for grafting purposes.

Providing an overhang of bone in this manner may also have anatomical advantages; for example, when diseased bone must be removed from the diaphysis of the upper end of the tibia close to the epiphysis, this can be accomplished without disturbing the tibial tuberosity and its tendinous attachment. It is important that all the diseased bone, or as much as is possible, should be removed, for such diseased foci as remain will form nuclei for the persistence of infection and will tend to interfere with complete and permanent epithelialization.

The margins of the skin incision are sutured to the periosteum and deep fascia along the border of the cavity left after saucerization. The cavity is then packed with sterile gauze. Fairly voluminous sterile dressings of gauze and wool are then applied and the limb is fixed on a simple splint. Two days later, the dressings and gauze packings are removed under nitrous oxide anaesthesia and the cavity is washed out with warm sterile saline solution and repacked. This procedure is repeated every two days for six days; anaesthesia is usually found to be unnecessary after the sixth day. The wound is now dressed daily and washed out with sterile saline solution. When the bone cavity is completely lined by healthy looking granulation tissue, the second stage in this operative treatment—the Thiersch grafting of the cavity—is undertaken.

Second Stage: Skin-Grafting of the Cavity

Stent's dental composition is sterilized by immersion in a watery solution of mercuric biniodide. The cavity to be grafted and the area from which the grafts are to be taken are prepared and draped in the usual manner. As much dental composition as is required to fill the cavity to

Fig. 2-A: Case 1. Wound prior to insertion of Stent's composition to make the mold.

Fig. 2-B: Stent mold covered with Thiersch grafts.

Fig. 2-C: Mold, bearing grafts, held in position in the wound.

Fig. 2-D: Mold held in position by means of gauze dressing and adhesive strapping.

Fig. 2-E: Two months after grafting, wound completely epithelialized.

FIG. 2-A

FIG. 2-B

FIG. 2-C

FIG. 2-D

FIG. 2-E

be grafted is now rendered malleable by immersion in thoroughly hot water, and the malleable mass is inserted into the cavity and, by gentle pressure of the fingers, is made to apply itself to all parts of the cavity and allowed to set hard. In this way an accurate mold of the cavity is obtained.

In those instances where both proximal and distal recesses, with an overhang of superficial bone, have been made, it is obvious that it will be necessary to use two separate molds of dental composition, each representing a portion of the cavity to be grafted, as the insertion or withdrawal of one complete mold when set hard would be impossible. (See Figure 1-B.) Sometimes the shape of the cavity, apart from the presence of both distal and proximal recesses, determines the necessity for using two separate molds, for, although the insertion of one complete mold is possible, it cannot be done without disturbing the grafts which it is to bear.

Those areas of the mold, or molds, which represent an accurate cast of the surface of the cavity are now covered with Thiersch skin grafts, their deep surfaces uppermost, and the mold, or molds, now bearing the skin grafts, are reinserted into the cavity. In order that the Thiersch

FIG. 3-A FIG. 3-B FIG. 3-C FIG. 3-D

FIG. 3-E FIG. 3-F

FIG. 3-G

Fig. 3-A: Case 2. Cavity in upper part of tibia completely epithelialized six weeks after grafting. Cavity in lower part of tibia ready for grafting.

Fig. 3-B: Same as Fig. 3-A. Lower cavity almost healed, three weeks after grafting.

Fig. 3-C: Roentgenogram of tibia before saucerization.

Fig. 3-D: Roentgenogram of tibia after saucerization.

Fig. 3-E: Roentgenogram of lower end of tibia before saucerization.

Fig. 3-F: Roentgenogram of lower end of tibia after saucerization.

Fig. 3-G: Lower cavity, completely epithelialized, five weeks after grafting.

grafts may be kept in firm contact with the granulations covering the walls of the cavity, it is necessary to maintain gentle but steady pressure on the mold after it has been inserted. This can be done quite easily by means of adhesive strapping. However, as the external surface of the mold is often concave, it is frequently desirable to apply a second piece of dental composition, external to the mold proper, in order to facilitate the application of pressure through the strapping.

Sterile dressings are applied and the limb may be bandaged to a simple splint. The mold is allowed to remain in position for ten days, during which time the limb is not disturbed at all; at the end of this time, the mold is removed. The major portion of the Thiersch grafts will be found

to be living and attached to the granulations around the walls of the cavity.

The cavity is now dressed daily. Warm normal saline solution is dropped in and gently blotted away with gauze. No packing is inserted into the cavity, but a light gauze dressing is applied across it as a shield. Epithelialization now proceeds rapidly and in the space of four to ten weeks, depending on the size of the cavity grafted, the patient's own individual potentialities toward healing, and other factors, the cavity is lined with a fairly thick layer of skin. As might be expected, this layer of skin is at first closely adherent to the bone, but, with the passage of time, a deposition of a certain amount of subcutaneous tissue appears to take place beneath the newly formed epithelium.

FIG. 4-A FIG. 4-B

Fig. 4-A: Case 3. Roentgenogram of right humerus before operation, showing extensive disease and sequestrum formation.

Fig. 4-B: After saucerization.

Fig. 4-C: Cavity completely epithelialized, ten weeks after grafting.

FIG. 4-C

The following cases have been observed for some considerable time since operation and in none of the cases have the epithelialized areas broken down to form fresh sinuses.

CASE REPORTS

CASE 1. A male, aged thirty, was admitted from another hospital where an operation had been performed for acute osteomyelitis of the right femur. Since operation, a large gaping wound, connected with a cavity in the right femur, had persisted and refused to heal for nine months.

No further operation was required on the femur itself. The large gaping wound was thoroughly cleaned and Thiersch grafts were applied over a mold of Stent's dental composition. Healing occurred in two months, during which the whole area of the wound became completely epithelialized. (See Figures 2-A, 2-B, 2-C, 2-D, and 2-E.)

CASE 2. A male, aged thirteen, had had chronic osteomyelitis of the left tibia with six discharging sinuses for four years. There had been occasional acute exacerbations of the condition, and operative interference had been necessary in one instance.

When admitted to the Royal Sea-Bathing Hospital, the patient had four discharging sinuses over the anterior aspect of the upper half of the left tibia and two over the lower

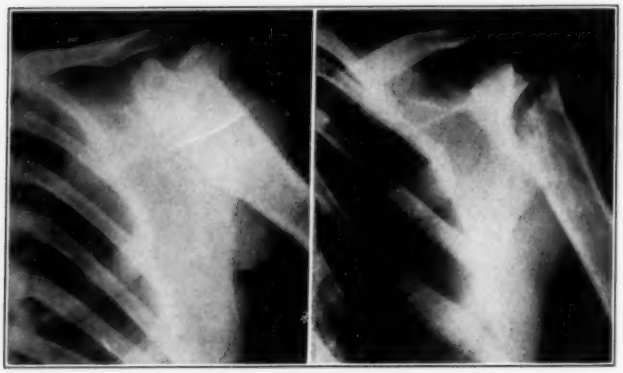


FIG. 5-A

FIG. 5-B

Fig. 5-A: Case 4. Roentgenogram of left shoulder joint, showing extent of disease and obliteration of joint space.

Fig. 5-B: After saucerization.

FIG. 5-C

Fig. 5-C: Cavity completely healed, twelve weeks after grafting.

third near the ankle joint. Roentgenographic examination revealed a large area of chronic osteomyelitis, with cavities, occupying the upper half of the tibia and a smaller area in the lower third.

The upper half of the left tibia was laid open, the sequestra were removed, and saucerization was performed. Care was taken not to prolong the saucerization too much proximally for fear of damaging the upper tibial epiphysis. Two weeks later, skin grafting of the saucerized area was done.

Ten days after grafting, the stent mold was removed, and, six weeks after grafting, the cavity had become completely epithelialized.

The cavity in the lower third of the tibia was dealt with in a similar manner, and complete epithelialization occurred five weeks after the skin grafting. (See Figures 3-A, 3-B, 3-C, 3-D, 3-E, 3-F, and 3-G.)

CASE 3. A male, aged sixteen, had had acute osteomyelitis of the right humerus four months prior to admission to the Royal Sea-Bathing Hospital. Two operations had been performed during the acute stage, and the right arm and shoulder had been put up in a plaster cast.

On admission, examination revealed extensive disease of the upper half of the right humerus with sequestrum formation, and three discharging sinuses. The shoulder joint was not involved.

Sequestrectomy and extensive saucerization of the upper half of the right humerus were performed and large sequestra were removed. Two weeks later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

FIG. 6-A

FIG. 6-B

Eight weeks after grafting, the operative site was almost completely epithelialized, except for two small areas. Ten weeks after grafting, the cavity was completely epithelialized. (See Figures 4-A, 4-B, and 4-C.)

CASE 4. A male, aged twenty-three, had had acute osteomyelitis of the left shoulder joint six months prior to admission to the Royal Sea-Bathing Hospital. The shoulder joint had drained at that time. A discharging sinus had persisted until admission.

On admission there was marked limitation of movement at the left shoulder joint with two discharging sinuses, one on the anterior aspect and one on the inferior aspect of the joint.

Roentgenographic examination revealed obliteration of the joint space and the normal joint markings, with destruction of the head of the humerus. Conservative treatment was tried for some time, with the arm and shoulder joint fixed on a splint. However, as the sinuses persisted and acute exacerbations with abscess formations occurred, radical operative treatment was finally resorted to.

The shoulder joint was opened, débris and the remains of the humeral head were removed, and diseased bone was excised from the upper end of the humerus and from the acetabulum. The skin edges were sewed to deep fascia and muscle, and the cavity was packed in the usual way. Three weeks later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

Six weeks after grafting, it was found that the grafts had taken well, but fairly large areas which had not yet be-

FIG. 6-C

FIG. 6-D

FIG. 6-E

FIG. 6-F

Fig. 6-A: Case 6. End of first stage of operation. The diseased area of the tibia has been laid open; sequestra have been removed; and the bone has been saucerized. The skin edges have been sutured to deep fascia and periosteum.

Fig. 6-B: Cavity covered with healthy granulation tissue, ready to graft.

Fig. 6-C: Showing two stent molds ready for covering with grafts.

Fig. 6-D: Showing the two molds inserted into the cavity.

Fig. 6-E: Eight weeks after grafting, cavity almost completely epithelialized, except for a few small areas.

Fig. 6-F: Ten weeks after grafting, cavity completely epithelialized.

come epithelialized persisted in the cavity. Nine weeks after grafting, almost the whole of the cavity had epithelialized. Eleven weeks after grafting, a small sequestrum separated in the floor of the wound. Twelve weeks after grafting, complete epithelialization had taken place. (See Figures 5-A, 5-B, and 5-C.)

CASE 5. A male, aged twenty-three, had had chronic osteomyelitis of the left femur of two years' duration, with a persistent sinus which discharged a profuse amount of pus. On admission to the Hospital, roentgenographic examination revealed an osteomyelitic area in the lower third of the femur, with a cavity containing a fairly large sequestrum.

Saucerization, with sequestrectomy of the lower end of the femur, was performed and a large sequestrum was removed. Ten days later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

Three weeks after grafting, the cavity was almost completely epithelialized; six weeks after grafting, there was only a small area in the deepest and lowest recess of the cavity which had not become epithelialized. Eight weeks after grafting, complete epithelialization had occurred.

CASE 6. A male, aged seventeen, had had chronic osteomyelitis of the left tibia of two years' duration, with multiple discharging sinuses.

FIG. 7-A

Fig. 7-A: Case 7. Probe inserted into sinus in connection with diseased area in lower end of tibia.

Fig. 7-B: End of first stage of operative treatment. The skin edges have been sutured to periosteum and fascia.

FIG. 7-B

Fig. 7-C: Four weeks after grafting, cavity completely epithelialized.

Fig. 7-D: Roentgenogram showing extent of cavity left after saucerization.

FIG. 7-C

FIG. 7-D

On admission, roentgenograms revealed a chronic osteomyelitic process involving the upper three-fourths of the left tibia, with sequestrum formation. The knee and ankle joints were not involved. There were nine sinuses over the anteromedial aspect of the upper two-thirds of the left tibia, all of which discharged pus fairly profusely.

The large sinus-bearing area was excised, the upper two-thirds of the tibia was laid open and large sequestra were removed, the bone was then saucerized, and the skin edges were sutured to periosteum and deep fascia around the large cavity. Four weeks later, the cavity was lined with fairly healthy granulation tissue, and skin grafting was performed. Because of the shape of the cavity, two stent molds were used. Ten days after grafting, the stent molds were removed.

Four weeks after grafting, there were some areas where epithelialization had taken place, but large unepithelialized areas persisted. Eight weeks after skin grafting, the unepithelialized areas were much smaller, and two weeks later there were only a few small areas which remained unepithelialized. Thirteen weeks after skin grafting, complete epithelialization had taken place. (See Figures 6-A, 6-B, 6-C, 6-D, 6-E, and 6-F.)

CASE 7. A male, aged twelve, had had chronic osteomyelitis of the lower end of the left tibia of three years' duration. During this time, acute exacerbations had occurred, with a persistent discharging sinus.

Roentgenographic examination revealed an osteomyelitic area and a cavity in the lower third of the left tibia.

The sinus was traced into the cavity in the lower third of the tibia. The cavity was laid open, the débris and some small sequestra were removed, and the diseased area of bone was saucerized. The skin was sutured to the margins of the cavity. Skin grafting of the cavity was done two weeks later. Ten days after grafting, the stent mold was removed.

Four weeks after grafting, the cavity had become completely epithelialized. (See Figures 7-A, 7-B, 7-C, and 7-D.)

CASE 8. A male, aged twenty-one, had had chronic osteomyelitis of the lower third of the left femur of four years' duration. Several acute exacerbations had occurred during this time, and there had been four persistent discharging sinuses.

On admission to the Royal Sea-Bathing Hospital, roentgenograms revealed a chronic osteomyelitic process in the lower third of the femur, with sequestrum formation.

Physical examination disclosed almost complete fixation of the knee joint in 50 degrees of flexion. This deformity was corrected completely by means of a hinged knee splint with continuous spring extension, and a considerable degree of movement was restored to the knee joint.

Sequestrectomy and saucerization of the lower third of the femur were performed. Four weeks later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

Seven weeks after grafting, the cavity had become almost completely epithelialized except for a very small area in its lowest recess. Nine weeks after grafting, the cavity was completely epithelialized. Seen as an out-patient fourteen months after operation, the patient was working as a motor mechanic, and the cavity had remained soundly healed.

COMMENTS

In presenting this method of dealing with the bone cavities left after radical operation for chronic osteomyelitis, no claims are made that the end results are superior to those obtained by the Orr method, the excellent results of which have been described by Kulowski. However, it has the advantage of promoting much speedier epithelialization and healing, and there is no unpleasant odor associated with it.

It has occurred to us that this method might, with advantage, be applied during Baer's maggot treatment at that stage when the wounds are filled with healthy, red granulations, when the reaction of the wound discharges is alkaline, and when pathogenic bacteria are few in number.

There is definite evidence that the deep but completely epithelialized cavities which result from this method of treatment tend to diminish in size with the passage of years.

NOTE: "Stent's composition" is a dental-impression composition extensively used in Great Britain, but any standard dental-impression composition will serve the purpose equally well.

REFERENCES

BAER, W. S.: The Treatment of Chronic Osteomyelitis with the Maggot (Larva of the Blow Fly). J. Bone and Joint Surg., XIII, 438, July 1931.

KULOWSKI, JACOB: The Orr Treatment of Osteomyelitis and Allied Suppurative Processes. A Statistical Analysis and Discussion of 155 Cases. J. Bone and Joint Surg., XIII, 538, July 1931.

FRACTURES OF THE FOREARM REDUCED BY DIRECT LEVERAGE *

BY J. E. M. THOMSON, M.D., F.A.C.S., LINCOLN, NEBRASKA

The method referred to as direct leverage has been employed by the author for the reduction of fractures in almost all of the long bones of the skeleton. Reports of this work have been read before various organizations and have appeared in the literature from time to time. Fifteen years of experience with this method has proved that it is particularly adapted to the reduction of a rather definite group of fractures of the forearm.

TYPE OF CASE

For the reduction of fractures of the forearm, direct leverage is indicated and recommended under the following circumstances:

1. When the ordinary methods of manipulation and traction have failed to bring satisfactory reduction of the fractured fragments.
2. In all fractures in which open operation is indicated, with perhaps the exception of those in which the fragments are severely comminuted or in compound fractures.
3. When one bone, either the radius or the ulna, is fractured and difficult to reduce.
4. When both bones are fractured and there is a greenstick fracture of one and overriding of the fragments of the other. In such a case, direct leverage of the overriding fragments will usually reduce this fracture without danger of completing the greenstick.
5. In fractures of both bones in which one fracture is reduced and there is overriding in the other. Direct leverage to the overriding fragments can usually be applied without loss of position in the other reduced fracture.
6. When, with the help of traction, full length of the fragments can be obtained, but apposition and alignment are difficult. The application of direct-leverage technique to the fragments will usually bring the desired anatomical position.

TECHNIQUE

This method requires the simplest type of operative procedure and the minimum amount of risk. It is relatively no more dangerous than the introduction of a local anaesthetic. It is often performed under local anaesthesia. A very simple set-up is usually all that is necessary,—a tray, a gown, a pair of gloves, a scalpel, a lever, and a few dressings. Any type of fluoroscope may be used. In the author's Clinic the head type of

* Presented at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

FIG. 1

Type of lever used.

fluoroscope is used, while at the hospitals the fluoroscopic table is employed. The fact that the arm can be turned from the anterior-posterior to the lateral position so easily before the fluoroscope has contributed a great deal to the adaptability of this technique to forearm fractures.

After the operator's eyes have become accustomed to the darkness, the patient's arm is held by assistants before the fluoroscope. The conventional rules of aseptic operative technique are followed by the operator and his assistants throughout the procedure. The lever is usually introduced through a stab wound on the dorsal side of the forearm over the site of fracture. The type of lever used is an ordinary dental chisel or straight dental instrument with a blunt point. The ends of certain dental instruments are often cut off for this purpose. Under the guidance of the fluoroscope, the lever is inserted between the fragments, so that the end of the lever impinges on one fragment and the shaft is against the other fragment. It is usually necessary to introduce the lever between the overriding fragments at a considerable angle. After the impingement is made, the lever is carried through an arc, the shaft bringing pressure in one direction on one fragment and the end of the lever bringing pressure in the opposite direction on the other fragment. In this manner, the overriding of the fragments is completely overcome. As the lever continues its course through the arc, one fragment is lifted while the other is depressed; apposition and alignment are obtained as the fragments glide and impinge into position when the lever is removed. Anterior-posterior plaster-of-Paris molded splints are usually applied, extending from the base of the fingers to the upper arm with the hand in dorsiflexion, and the arm in supination or midsupination, depending upon the type and position of the fracture. The forearm is flexed on the arm at an angle of 90 degrees. Padding is seldom used except in the form of light

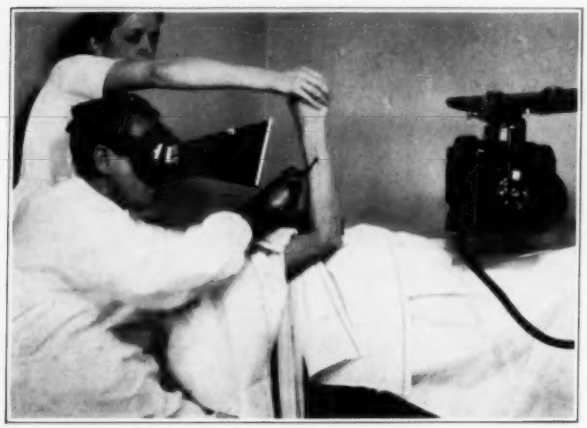


FIG. 2

Direct leverage as performed with a head fluoroscope and shock-proof x-ray unit.

FIG. 3-A

FIG. 3-B

Anteroposterior and lateral x-rays of radius and ulna. Both bones were fractured and there was overriding at different levels. The fracture of the radius has been reduced, but the fragments of the ulna remain overriding and displaced.

FIG. 4-A

FIG. 4-B

Lateral and anteroposterior x-rays showing reduction after direct leverage through a window in the cast.

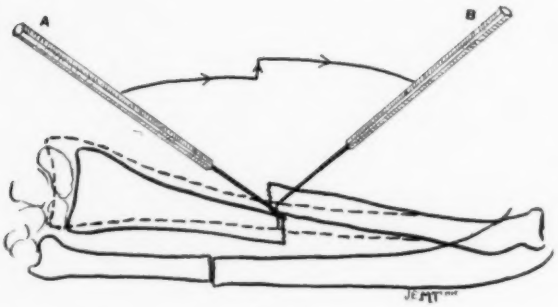


FIG. 5

Drawing showing a fracture of the radius and ulna at different levels: the fracture of the ulna is reduced; the fragments of the radius are overriding after attempted reduction. *A* represents the position of the lever at the beginning of reduction. The end of the lever is against the lower fragment, and the shaft of the lever is against the upper fragment. The lever is carried through the arc, as indicated by the arrows, thus overcoming the overriding and depressing and lifting the upper and lower fragments into apposition. The dotted line represents the reduced fracture. *B* shows the position of the lever after it has been carried through the arc necessary to bring about reduction.

felt pads about the elbow and the upper and lower ends of the splint.

Direct leverage has followed the use of Kirschner-wire traction and countertraction in the olecranon and lower forearm when there is difficulty in attaining adequate apposition and alignment. Occasionally, direct leverage has been performed through a window in the cast over the site of the deformity in cases in which the fracture was apparently well reduced and splinted, but in which a subsequent roentgenographic check-up showed an overriding of the fragments in one of the fractures. In a few instances, it has been necessary to leave the lever embedded between the fragments in order to insure apposition. When this is necessary, the lever is embedded in the plaster-of-Paris cast and removed in a week or ten days without danger of losing the position.

In a few instances where a fluoroscope was not available, a small incision was made over the fragments and the leverage procedure was followed with the fragments in sight, without extensive exposure or injury to soft tissues or bone.

RESULTS

This report is based upon a study of 362 consecutive patients with fractures of the forearm, treated by the author during the past fifteen years. Incomplete records and insufficient follow-up data made it necessary to omit eighty-five of these patients from this study. Among these were seven who had had fractures which had been successfully reduced by direct leverage, without complications, but, due to the fact that they had left the author's care and had returned to distant homes within the first few weeks, they could not be contacted for follow-up data. However, it may be assumed that they made satisfactory recoveries within the expected time, for in the author's experience any fracture patient who has trouble or complications of any kind will return with the bad tidings from far or near and spread the sad news to all who will listen.

In the 277 remaining patients, counting those who nad fractures of both arms and those in whom both the radius and ulna of one arm were

fractured, there was a grand total of 377 fractures of the forearm. The fact that 110 of these patients, or practically 40 per cent., had had unsuccessful attempts at reduction from a few days to several months prior to being referred to the author seems of unusual interest. In other words, 40 per cent. of the patients in this series presented more than the ordinary problems in the reduction of the fractures. Eighty-six per cent. of the fractures in the entire series requiring operative procedures—open operation or direct leverage—came within this group. In 377 fractures of the radius and ulna, direct leverage was used in forty-six instances. It was used about an equal number of times in fractures of the lower and middle thirds of the radius and ulna and twice in fractures of the upper third of the ulna.

A careful study of the end results revealed the fact that in cases of fractures reduced by direct leverage the period of disability was no longer than in those in which simple closed methods of reduction were employed. Also, in the few cases in which the lever remained embedded in the cast for a week or ten days, the period of disability was no longer than that of the group in which simple closed methods of manipulation were used. However, in the fractures of the forearm requiring extensive open operative procedures, the period of disability was very much increased and often doubled, and the amount of partial permanent disability was much greater than in those fractures reduced by direct leverage and simple methods. In every instance in which direct leverage was used, not only were good apposition and alignment and an average period of disability obtained, but there were excellent functional results. Not a single infection resulted in the entire series.

CONCLUSION

Those who discussed the author's early reports of this method recognized its merit, although they drew attention to the dangers of introducing a foreign body between the fragments,—the possibility of infection, the promotion of delayed union, and the peril of injury to the tender soft-tissue structures.

This review of 377 fractures of the forearm shows that there was a certain definite group of these fractures (forty-six) in which reduction could not be obtained by ordinary methods, and in which rather extensive open operative procedures would usually be indicated. However, these fractures were reduced by the technique of direct leverage, with results equal to those obtained in non-problem fractures in which simple methods of reduction were adequate.

AMPUTATION FOR SARCOMA OF THE NECK OF THE FEMUR BY THE INTERINNOMINO-ABDOMINAL METHOD

BY R. R. FITZGERALD, F.R.C.S. (ENG.), MONTREAL, CANADA

From the Children's Memorial Hospital, Montreal

In 1891, Billroth made the first attempt to remove the whole lower extremity, together with the innominate bone. The case was not published, but, when Savariaud wrote his article on the subject in 1902, Billroth was given the credit for being the first to carry out the procedure. This operation has not often been practised, but, in the years that have intervened since Billroth's venture, a number of surgeons have had occasion to attempt it, and in 1935 Gordon-Taylor and Wiles were able to assemble from the literature data on fifty authentic cases. To this number, they added five cases of their own, bringing the total to fifty-five. Since the appearance of that paper, Gordon-Taylor has added another successful (unpublished) case.

In the history of the evolution of the operation, the difficulties involved have been surmounted one by one.

Incisions to give adequate flaps have been suggested by Jaboulay, Girard, Bardenheuer, Salistschef, and Savariaud. That proposed by Girard has been the most useful, and is now always employed unless local conditions demand some modification.

Hemostasis was secured in some of the early cases by the Momburg tourniquet, but of late the ligation of the external iliac vessels has been practised. The common iliac artery cannot be tied without endangering the flaps.

Spinal anaesthesia was employed by Gordon-Taylor and Wiles in conjunction with ether. In the author's case, spinal anaesthesia alone was used.

The prevention of shock, by lowering the head of the table, by the administration of ephedrine hypodermically when the blood pressure falls, by the injection of the large nerves with novocain solution before they are divided, and by the transfusion of blood at the close of the operation, has finally made this seemingly forbidding procedure relatively safe. Although Gordon-Taylor and Wiles found a mortality of 56.4 per cent. in the fifty-five cases that they collected, they were able to report that four out of five of their own patients had survived.

The operation has been used in attempts to cure primary sarcoma of the bone or of the soft tissues, chondrosarcoma, tuberculosis, osteoclastoma, myxosarcoma, and infective osteomyelitis. Geschickter and Copeland have drawn attention to the fact that, in cases of tumor in which bone formation is a pronounced feature, amputation has saved a considerable number of patients (26 per cent. of their series).

The operation may be carried out as a single-stage procedure, or it

may be done in two stages,—that is, disarticulation at the hip followed later by removal of the innominate bone.

CASE REPORT

A colored boy, thirteen years old, was admitted to the Children's Memorial Hospital on April 17, 1935. He had had no previous illness except mild bronchitis in infancy. Five weeks before admission he had fallen at play, striking his right knee on the ground. This injury had been followed by pain in the right hip, and a limp had developed. The limp had gradually grown worse, and the pain had increased in severity, becoming constant throughout the day and disturbing his sleep in the early mornings. His appetite had failed.

On examination, there was found wasting of the whole extremity. The right thigh measured one inch less in circumference than the left, and the right calf one-half an inch less than the left. The hip was flexed, abducted, and rotated outward. The range of movement was restricted by pain. There was tenderness over the upper end of the femoral shaft. Roentgenographic examination showed a destructive lesion involving the anterior portion of the femoral neck and the upper part of the shaft. On May 14, under ether anaesthesia, a fragment of a soft vascular mass attached to the femoral neck was removed for diagnosis through an anterior vertical incision. Histological study showed that the tumor was an osteoblastic osteogenic sarcoma, with extensive bone formation.

Amputation was accordingly advised, but was declined by the parents. In a few days, a swelling became visible at the site of the incision, and a course of seven injections of Coley's fluid was given without evident effect. The pain gradually became unbear-

FIG. 1

Photograph before operation, showing tumor of the thigh and biopsy wound beginning to break down at its center.

FIG. 2

Patient on discharge, twenty-two days after operation.

able, the exploratory wound opened spontaneously, and a hemorrhagic discharge appeared. At this stage (Fig. 1) permission for amputation was given. A second roentgenogram, taken immediately before the operation (Fig. 5), revealed rapid advance in the size of the tumor, increased destruction of the femoral shaft, and extensive bone formation.

Operation

On June 18, 1935, under novocain anaesthesia, an amputation of the right limb was performed by the interinnomino-abdominal method. The preoperative medication was as follows: One hour before operation, one grain of nembutal was given by mouth; one-half an hour before operation, a second dose of one grain of nembutal was given orally, together with one-eighth of a grain of morphine and one three-hundredths of a grain of atropin hypodermically. For the anaesthetic, 150 milligrams of crystalline novocain was dissolved in five cubic centimeters of spinal fluid through lumbar puncture.

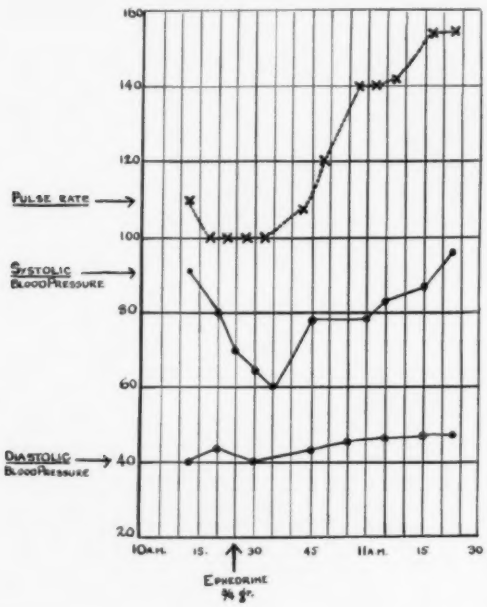


FIG. 3

Chart showing pulse and blood pressure during interinnomino-abdominal amputation.

The head of the table was lowered, and the patient was placed on his back and rolled over slightly toward the sound side, with sand pillows behind the right shoulder and hip. The left leg was tied to the table to prevent sliding.

The incision, as proposed by Girard, began at the right posterior-superior iliac spine, followed the iliac crest and the inguinal ligament to the pubic spine, and then turned downward at the perineoscrotal junction to the medial surface of the thigh. The muscles were detached from the iliac crest, and the iliac fossa was palpated for intrapelvic extension of the growth. None was found. The inguinal ligament was detached from the anterior-superior spine and the external iliac artery was ligated with silk. The femoral nerve was injected with novocain and divided. The external iliac vein was then ligated with catgut; the interval between the ligation of the artery and of the vein permitted most of the blood in the extremity to return to the trunk. The spermatic cord was retracted medially, and the origins of the rectus abdominis and pyramidalis muscles were separated from the pubic crest. The pubic symphysis was cut through with a knife. The patient was then turned completely onto his left side. A vertical incision was made, beginning just behind the midpoint of the iliac crest and extending down to the gluteal fold and around the back of the thigh to meet the medial end of the first incision. The iliac bone was exposed; the superior gluteal artery was tied; and the bone was cut through from the crest to the sacrosciatic notch with a Gigli saw. The obturator vessels were then ligated and divided inside the pelvis. The obturator and sciatic nerves were injected with novocain solution and divided. In successive stages, the piriformis was divided; the inferior gluteal vessels were tied and cut; the levator ani, the psoas muscle, and the sacrotuberous ligament were divided; and the limb was removed from the body. The peritoneum was

FIG. 6

Roentgenogram of the pelvis after interinnominoabdominal amputation.

FIG. 5

Roentgenogram just before operation, showing increase in bone destruction, bone formation, and size of the growth.

FIG. 4

Roentgenogram on admission, showing destructive lesion involving the neck of the right femur.

not opened. The edges of the abdominal muscles were drawn downward and sutured to the remains of the glutei and the levator ani to form a muscular layer. A cigarette drain was inserted in the extraperitoneal space. Finally the skin was sutured.

A transfusion of 500 cubic centimeters of citrated blood was begun during the closure of the wound. The child was returned to his bed in good condition one hour and twenty minutes after the administration of the anaesthetic was begun.

FIG. 7

Photograph of the femur, innominate bone, and tumor.

The extent of shock during the operation is shown in Figure 3. The pulse was 108 at the beginning of the operation, and remained at that level for thirty-five minutes. It then rose gradually to 152 at the close. After transfusion, it fell to 120. The systolic blood pressure fell from 88 to 60 in thirty minutes. At this time three-quarters of a grain of ephedrine was given hypodermically. This was followed by a rise in systolic pressure to 80 and at the end of the operation it was 88. The diastolic pressure rose steadily during the operation period. There was thus very little operative shock. The child did not complain of pain during the procedure.

The patient made a good recovery and left the hospital walking with crutches on the twenty-second day after operation (Fig. 2). The roentgenogram made on discharge from the hospital is reproduced in Figure 6.

Pathological Examination

Figure 7 shows the denuded femur and innominate bone with the growth. The tumor sprang from the bone on the anterior surface of the femoral neck, and spread upward, downward, and around the shaft in the soft tissues. The head of the bone was not involved; the pelvic bones were also free from growth.

Histological Report

"The tissue consists of spicules of bone, or of osteoid tissue surrounded by layers and masses of large osteoblastic cells. The nuclei are large, oval, and vesicular with a single pink nucleolus when stained by the trichrome method of Masson. The nuclei occupy at least half of the cell body. Most of the cells have a rim of basophilic cytoplasm, and some seem to have a centrosome. A few have almost no cytoplasm. Quite often there is a tail of cytoplasm streaming out into the tissue. Mitotic figures are fairly common. These tumor cells, probably of osteoblastic origin, are arranged in layers about the bone spicules, and are not flattened against the bone like normal osteoblasts. There are a fair number of tumor giant cells; the younger ones have a basophilic cytoplasm; the older, eosinophilic with smaller nuclei and granular or vacuolated cytoplasm. There are usually not more than six nuclei in each giant cell. The advancing sides of the tumor areas have a narrow strip of loose fibrous tissue, the nuclei of which are arranged in parallel rows. Some of these fibrous-tissue cells show mitosis, and the impression is gained that these cells too are undergoing malignant change. The advancing edge of the tumor is in a straight line; no irregular infiltration can be seen. *Diagnosis:* Osteoblastic osteogenic sarcoma."

BIBLIOGRAPHY

BARDENHEUER: Exarticulatio femoris im Iliacal-Gelenke. Verhandl. d. Deutschen Gesellsch. f. Chir., XXVI, I, 130, 1897.

GESCHICKTER, C. F., AND COPELAND, M. M.: Tumors of Bone. New York, The American Journal of Cancer, 1931.

GIRARD, CH.: Désarticulation de l'os iliaque pour sarcome. Congrès Français de Chir., IX, 823, 1895.

GORDON-TAYLOR, G., AND WILES, PHILIP: Interinnomino-Abdominal (Hind-Quarter) Amputation. British J. Surg., XXII, 44, 1935.

JABOULAY: La désarticulation interilio-abdominale. Lyon Méd., LXXV, 507, 1894.

JUDIN, S. S.: Ilio-Abdominal Amputation in a Case of Sarcoma; Recovery: Pregnancy and Birth of Living Child. Surg. Gynec. Obstet., XLIII, 668, 1926.

LERICHE, RENÉ, ET STULZ, EDGAR: Remarques sur la technique de la désarticulation inter-ilio-abdominale. Presse Méd., XLIV, 65, 1936.

PRINGLE, J. H.: Some Notes on the Interpelvi-Abdominal Amputation, with a Report of Three Cases. Lancet, I, 530, 1909.

The Interpelvi-Abdominal Amputation. British J. Surg., IV, 283, 1916.

SALISTSCHEF, E. G.: Exarticulatio interileo-abdominalis. Arch. f. klin. Chir., LX, 57, 1899.

SAVARIAUD: Cas de désarticulation inter-ilio-abdominale. Procédé à lambeau interne. Rev. de Chir., XXVI, 345, 1902.

END RESULTS IN 100 FRACTURES TREATED BY INTERNAL REMOVABLE FIXATION *

BY W. B. CARRELL, M.D., DALLAS, TEXAS

Professor of Orthopaedic Surgery, Baylor Medical School

In presenting methods of fixation of fractures requiring open surgery, it is presumed that those having the responsibility of treating difficult fractures are familiar with the principles of traction and manipulation and are prepared to operate when the circumstances require it. It is difficult to outline the indications for operative treatment because the factors of individual judgment and surgical skill are so important and identical results may be obtained by two surgeons using entirely different operative methods. Likewise, if a surgeon decides upon an open reduction, the proper method is that which in his experience has proved satisfactory. It would seem sound practice to have a working familiarity with several methods of fixation, but to understand thoroughly the application of a few well-selected appliances and to adapt them to varying conditions.

The method of fixation with a removable screw, described by Girard and the author [1], has been used in our Clinic for several years and in more than 100 cases. The simplicity of the operative technique and the excellent results obtained warrant further observation on this method.

If the fracture is comminuted or compound, the screw is not suitable for fixation. Oblique fractures are best for this type of fixation, but transverse fractures can be fastened satisfactorily by this method. For transverse fractures, a compression staple was designed, but this has rarely been used because a screw placed in a long oblique position seems more desirable.

TECHNIQUE

The technique is essentially the same as that described in the original publication [1], but, for convenience and to include some variations, the method is here outlined.

The fracture is exposed and reduced.

The fragments are grasped with a clamp and held securely for drilling. At this stage, careful attention is given to placing the drill holes. The object is not only to hold the ends approximated, but also to produce compression. The latter can be accomplished better if the screw is placed as nearly as possible at a right angle with the broadest surface of the fracture line. The screw of rustless steel is made in two sizes and four lengths. The distal end has deep wood-screw threads, which were found to have more resistance in cortical bone than the machine threads formerly

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

used. A small beveled lock nut moves on the otherwise machine-threaded screw, and a wing nut is fixed on the end to facilitate introduction. The proper size of the screw is determined by estimating the length necessary to cause the screw to extend one-half an inch to two inches beyond the skin. The first drill hole must be slightly larger than the screw and should extend only through the first or proximal fragment. Chipping the cortical surface facilitates starting the drill. The drill should be in good condition, for a dull drill makes a simple procedure difficult. When the drill has penetrated to the second fragment, it is removed and replaced by a drill slightly smaller than the screw. The author has had difficulty in obtaining good drills of this size. Often considerable length is required because the second drill should penetrate the distal cortex; when the screw is to be placed in an extremely oblique position, as for a transverse fracture, four or five inches of drill length may be required. The most practical type of small drill is one made from rustless steel and sharpened as is a Kirschner wire. Several lengths are available and there is no danger of breaking, as has occurred several times in the writer's experience with long hard drills of small caliber.

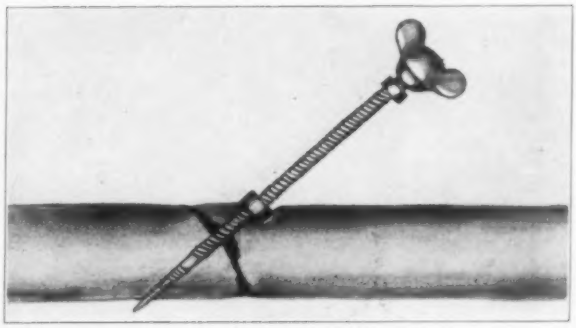


FIG. 1

Carrell-Girard screw. Note the deep threads at the end of the screw and the machine threads on the proximal three-quarters of the screw.

After the second drill hole has been completed, the screw is inserted. It then passes freely through the first fragment and engages the second. The wing nut, fixed on the proximal end of the screw, enables one to extend the screw to the desired depth with finger pressure. The small nut, which moves freely on the screw, is now brought firmly against the proximal fragment and tightened with pliers.

If the screw falls in line with the incision, the latter is closed around it. The end of the screw which projects beyond the skin is covered with dressing. Should it be found desirable to place the screw at some other angle than one conforming to the line of incision, it can be placed through a stab wound, preferably after the drill holes have been completed. The screw will then be away from the line of incision, which is to be desired when feasible.

Formerly, the end of the screw was anchored securely to give an added point of fixation. Theoretically, this is correct and should be done when the plaster is closely applied as in the case of the forearm or the leg. In the case of the femur or the humerus, there is always slight movement of

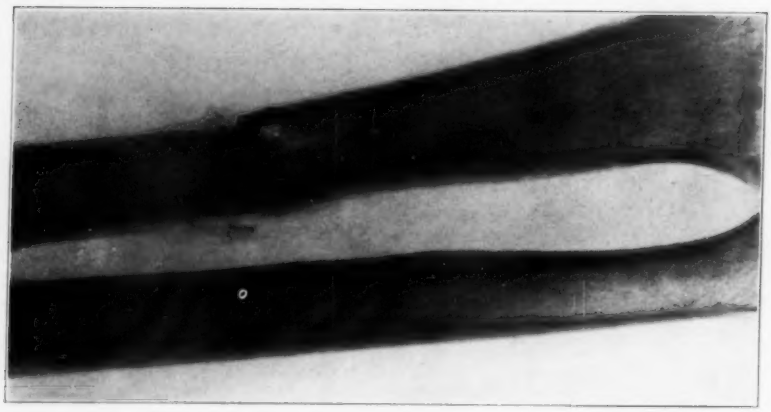


FIG. 2-C
Union has taken place in seven weeks.

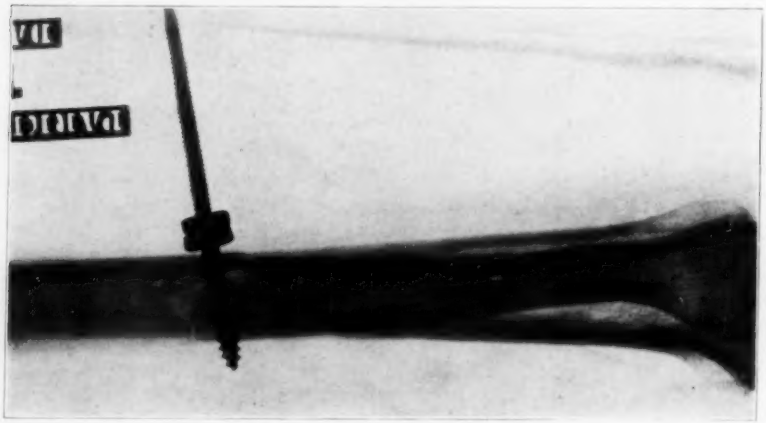


FIG. 2-B
Removable screw in place.

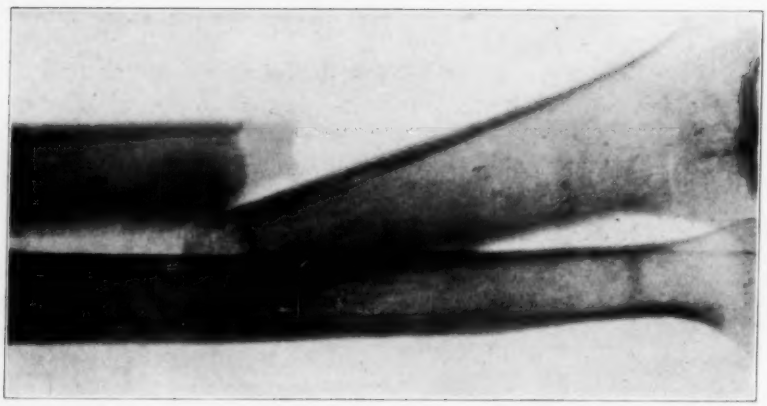


FIG. 2-A
Recent fracture of the radius, ten days after injury. Manipulation unsuccessful.

the part within the plaster and, to compensate for this, the plaster is cupped around the end of the screw, but is free enough to permit a little movement. However, it rests snugly against the end of the screw, which controls the tendency to deviation of the fragments.

After completion of the dressing, which always includes plaster fixation, the operative wound is not disturbed for three weeks. At this time, a window is cut, the stitches are removed, and, if the roentgenograms show adequate callus, the screw is also removed. In no case has it been found necessary to leave the screw in position longer than four weeks. At the time of removal, the screw will be tightly fixed, but, by means of a few turns, it may be released readily. Since the lock nut is beveled, it may be drawn through the muscles and the fascia without undue tension. Patients frequently leave the hospital after a few days and return to the office for removal of the screw.

FINDINGS

This method of fixation has been used in slightly more than 100 cases. A few of these were compound fractures. Several other cases have been

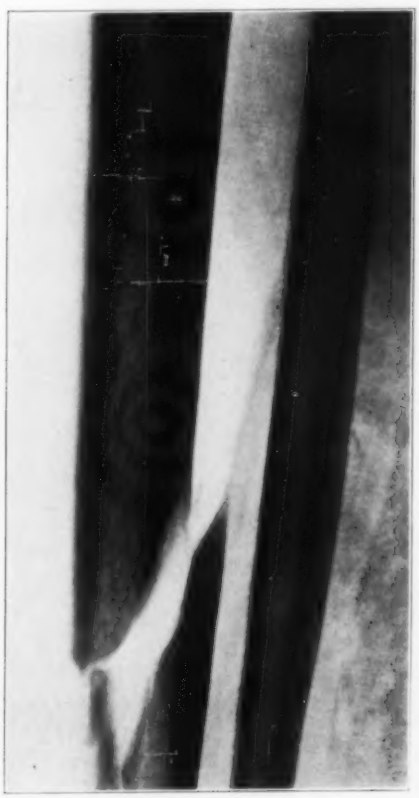


FIG. 3-A

Fracture of the tibia, after manipulation and traction for five days.

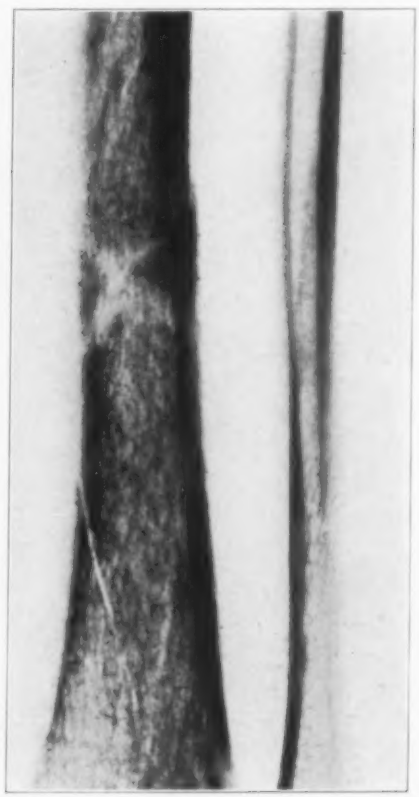


FIG. 3-B

Six weeks after removal of the screw; nine weeks after operation.

treated by this method during the past few months but are not included in the report.

Non-Union and Union

In 100 consecutive cases of clean fractures, there was one case of non-union. This was a fracture of the forearm in which two manipulations under anaesthesia had been done and the fragments were in malposition two weeks after the injury when the open reduction was performed. The fracture in the middle of the radius, which was treated by closed reduction, united. The fracture in the middle of the ulna, which was reduced at open operation and fixed with a screw, did not unite and later a bone-grafting operation was necessary.

FIG. 4-A

Comminuted fracture of the tibia four months after injury, with malunion.

FIG. 4-B

Open reduction has increased the length three-quarters of an inch without detaching the upper segment of the fracture. The lower segment is held in contact with the removable screw. The fibula has been divided to gain length.

FIG. 5-A
Fracture of the olecranon.

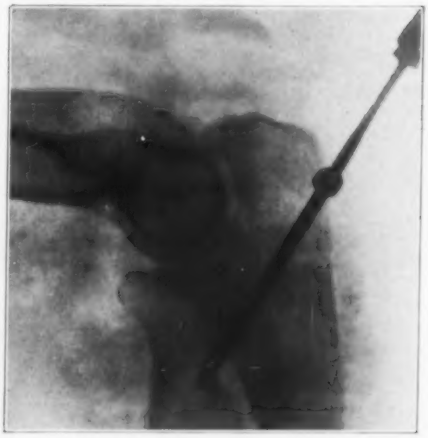


FIG. 5-B
Fragments held in position by the screw.

FIG. 5-C
Four weeks after injury.

In 60 per cent. of the cases, two or more manipulations had been done prior to operation. Union was a little more rapid in those cases in which several manipulations had not been done. Union was more rapid in the few cases in which the operation was performed within forty-eight hours than it was in those cases in which the operation was postponed for eight or ten days, as was done in most of the cases. In the entire series, the time required for union was approximately 25 per cent. longer than for similar cases in which good position of the fragments could be effected early and by closed reduction. However, union was approximately 35 per cent. faster than in similar cases where the reduction was not very satisfactory, but was considered good enough to make operation unjustifiable and to warrant treatment by closed methods.

In addition to the more rapid union, the incidence of non-union (1 per cent.) was much less than in the group of similar fractures in which only fair reduction had been obtained and which had been treated by closed methods.

Infection

In no cases in the group of simple fractures did bone infection develop. Most of the wounds remained dry up to the time of the removal of the screw, when serum moisture was evident for a few days. In a few cases

FIG. 6-C
Union in ninety days.

FIG. 6-B
Open reduction; very little callus; fixation by two screws.

FIG. 6-A
Compound fracture of the femur, four months after injury. Skeletal traction had been maintained for sixty days.

FIG. 7-C
Two months after operation; very good union.

FIG. 7-B
In attempting to reduce the fracture by the open method, a large fragment was almost detached. Osteotomy of the fibula was then done to lessen the difficulty of reduction. Fixation of the fragments was obtained by a screw.

FIG. 7-A
Oblique comminuted fracture of the lower third of the tibia. Traction had been applied for one week. Length had been secured, but poor contact of the fragments had resulted.

(10 per cent.), there was at the time of removal of the screw considerable soiling of the dressing around the screw, but this condition cleared up within a few days without contamination of the bone. In the earlier cases, this method was employed with some trepidation in anticipation of this added source of contamination. It seemed that we were violating a surgical principle in carrying a foreign body through the skin to the site of a simple fracture. Therefore, it has been our purpose to carry out a most meticulous technique for exposing and reducing the fracture. The tissues are handled gently and when the operation is finished the field is left perfectly dry. The sterile dressings, applied immediately after the operation, are left undisturbed for the long period to avoid chances of contamination. The operation unquestionably offers more opportunity for infection than does a closed operation where there is no foreign body projecting through the skin.

Final Position on Healing

The screws held the fragments in whatever position they were placed at the time of operation. In 14 per cent. of the cases, there was some comminution and an accurate reposition could not be done. In these cases, union was slow, but satisfactory function was finally obtained. For this type of fracture a screw should not be used and, if open operation is necessary, some other method of fixation should be applied. In 20 per cent. of the cases, there was some change in the position of the fragments after removal of the screw; in most of these cases, there was a slight deviation, such as outward bowing of the femur or posterior bowing of the ulna. This defect has been better controlled in the more recent cases by careful attention to splinting after removal of the screw. In fractures of the femur, where this tendency is greatest, a compression pad should be placed against the thigh after removal of the screw. In the window which is cut for removal of the stitches and the screw, a firm pad is placed and held by a metal pad with a turnbuckle compressor in order that position may be maintained until the bone is firm enough to resist muscle contraction.

ADAPTABILITY

The method has been used satisfactorily for oblique and transverse fractures in the shafts of all of the long bones of the extremities with the exception of the fibula. It is particularly suited to the fixation of fractures of the olecranon, because the olecranon fragments can be securely fastened and permit a right-angle position for ambulatory treatment. This procedure should not be used in comminuted fractures, or in compound fractures. One compound fracture was perfectly reduced and fastened with a screw. Both fragments necrosed up to the point where the drill hole was placed. In cases where the fragments can be fairly accurately replaced, this method is not as good as the closed method of treatment.

1. Carrell, W. B., and Girard, P. M.: Removable Internal Fixation in Fractures. J. Am. Med. Assn., XCVI, 670, 1931.

PELVIC ABSCESSES ASSOCIATED WITH ACUTE PURULENT INFECTION OF THE HIP JOINT *

BY JOSEPH A. FREIBERG, M.D., CINCINNATI, OHIO

AND ROBERT PERLMAN, M.D., BROOKLYN, NEW YORK

From the Department of Orthopaedic Surgery, University of Cincinnati

Acute purulent infection of the hip joint is not a rare disease. Consequently, medical literature contains many articles concerning this subject, but only two factors are stressed,—the type of surgical drainage and the type of immobilization. Little can be found regarding the mode of infection and the complications. To summarize the literature on pyarthrosis of the hip joint, the important items are early diagnosis, surgical drainage by one of several anterolateral or posterior approaches, and immobilization in traction or a plaster cast. If the infection is not severe, the treatment advocated consists of aspiration and immobilization, or immobilization alone[5].

During a period of eleven months on the Orthopaedic Services of the Children's Hospital and the General Hospital, Cincinnati, seven cases† of purulent infection of the hip joint were encountered in which the joint infection was associated with adenitis of the inguinal lymph nodes and iliac abscess. The early appearance of the iliac abscess, which was present in the majority of the cases on admission to the hospital, offered considerable difficulty in diagnosis. Did the abscess represent an appendiceal abscess, an osteomyelitis of the ilium, or an idiopathic retroperitoneal abscess? The children, varying in age from six to fifteen years, were all acutely ill and required immediate attention. Four patients in this series had a septicaemia, and five of the seven had a recent or existing otitis media or mastoiditis. Because of the bizarre clinical picture, two of the children were subjected to immediate laparotomy; due to a mistaken diagnosis, one of these patients was operated upon for an appendiceal abscess. Six of the seven patients had iliac abscesses on the right side. Although hip symptoms existed, irritation of the iliopsoas muscle was thought to explain these findings. Later study of the roentgenograms showed early changes in the hip joint, but these could easily have been overlooked.

In a consideration of the association of iliac abscess and purulent infection of the hip joint, the question may well be raised: Did the iliac abscess precede the involvement of the hip joint, or vice versa? On consulting the literature, the authors found just two articles on this subject. Sáinz de Aja[6] reported a case of staphylococcic coxitis with complication of the inguinal glands. However, this patient was a male adult who had, in addition to an infected hip, an active gonorrhoeal infection, which rather

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.

† See note, p. 427.

complicated the picture. Gravinghoff[3] reported two cases of infants with extensive multiple osteomyelitic foci, who had retroperitoneal abscesses. The lesions were not confined to the hip joints and the clinical pictures were far from clear.

Slowick[7], in reporting sixty cases of purulent infection of the hip joint seen in the Boston City Hospital over a period of fifteen years, did not mention the occurrence of iliac abscess. He states: "The occasional case of an abscess outside of the capsule of the hip joint does not present any unusual difficulties." In the sixty cases, drainage was accomplished by posterior incisions in thirty-two cases, anterolateral incisions in twenty-seven cases, and an undescribed medial incision in one case. Did this one case represent a pelvic abscess?

FIG. 1

Lymphatic drainage of the anterior and superior surfaces of the hip joint. The glands lie along the external iliac artery. (From paper by C. N. Alivisatos[1]. *Reproduced by courtesy of Masson & Cie, Paris.*)

Caldwell[2] reported eighteen cases of purulent infection of the hip in children under fourteen years of age, in which the drainage was accomplished by anterior incisions in twelve cases, by posterior or Ober incisions in two cases, and, in four cases, by incisions on the inner aspects of the thighs where the abscesses were pointing. On reading this article, one concludes that in these four cases the mesially pointing abscesses were extensions from the hip-joint infections, but were they not pelvic abscesses?

Guthrie and Middleton[4] reported a case of left-sided mastoiditis with lateral sinus thrombosis in which a purulent infection of the right hip joint developed. Drainage of the hip joint was done through a lateral incision, but satisfactory convalescence did not begin until through-and-through drainage was established from the hip joint to the adductor region. The possibility of a pelvic abscess presenting in the adductor region was not considered.

It is evident from the foregoing references that the presence of pus in the adductor region of the thigh has been noted in a number of instances in association with pyogenic infections of the hip joint. The possibility that these abscesses do not represent direct extension of the hip-joint infection has not been considered.

There is a unanimity of feeling regarding the manner of infection of the hip joint,—namely, that the infection is hematogenous, except in those instances in which it occurs directly from without. Whether or not the hip joint becomes infected by extension from a neighboring lesion of the innominate bone does not concern this discussion. Suffice it to say that, in the seven cases to be presented, the primary lesion in the hip joint was either synovial, cervical, or epiphyseal, as indicated by the roentgenographic findings. In no case were there clinical or roentgenographic findings suggesting the presence of osteomyelitis of the ilium or perforation of the acetabulum by infection.

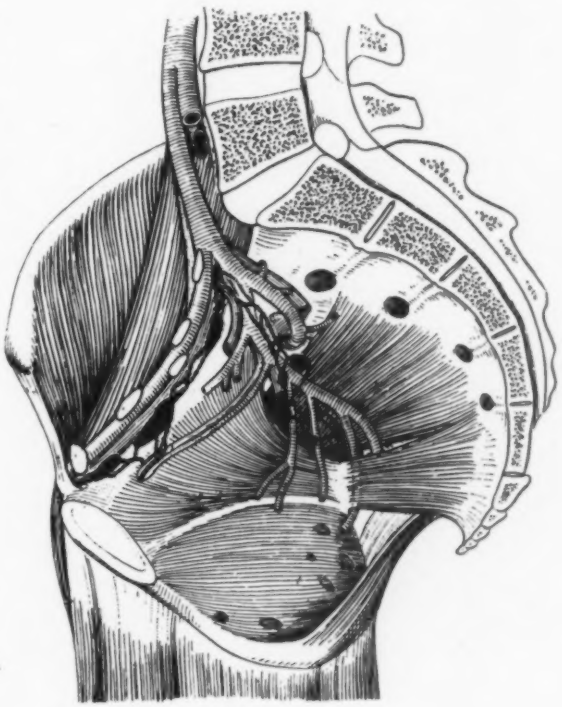


FIG. 2

Lymphatic drainage of the posterior and inferior surfaces of the hip joint. In this sagittal section, the glands are shown lying along the hypogastric artery, as well as the external iliac glands. (From paper by C. N. Alivisatos[1]. *Reproduced by courtesy of Masson & Cie, Paris.*)

A careful study of many of the text-books and publications concerning the lymphatic drainage of the hip joint fails to show a single dissenting opinion. All writers agree that the intracapsular structures of the hip joint are drained by lymphatics emptying into the group of glands situated about the external iliac artery, except a portion of the hip joint posteriorly in which drainage is into the glands about the hypogastric artery. These two groups of glands, variable in number, drain into the glands about the common iliac artery, and connect with the more proximally situated presacral glands. The superficial inguinal glands, which drain the anterior two-thirds of the perineum, and the femoral glands, which drain the leg, combine as a single group and have

afferent lymphatics draining into the external iliac glands. Likewise, the single gland of Cloquet or Rosenmüller, situated beneath Poupart's ligament, just mesial to the femoral vein, drains into the external iliac chain[1]. (See Figures 1 and 2.) The external iliac glands, grouped about the artery, are retroperitoneal and lie immediately over the thin enclosing sheath of the iliopsoas muscle. Infection of the external glands by extension along the lymphatics from the hip joint may be followed by necrosis and abscess formation, the abscess lying on the iliopsoas muscle. It is well recognized that an increasing abscess in this location extends upward in the false pelvis and gravitates downward either into the true pelvis or along the iliopsoas muscle. As this abscess lies anterior to the iliopsoas muscle, it would tend to extend mesially and downward, presenting either on the anterior surface of the pectineus muscle, and thence beneath the skin, or along the pectineus muscle and downward between the adductor longus and the adductor brevis muscles. As the iliopsoas muscle extends anteriorly over the hip joint in its course distally, it would seem unlikely that an abscess situated on the anterior surface of this muscle would extend to or into the hip joint or its capsule.

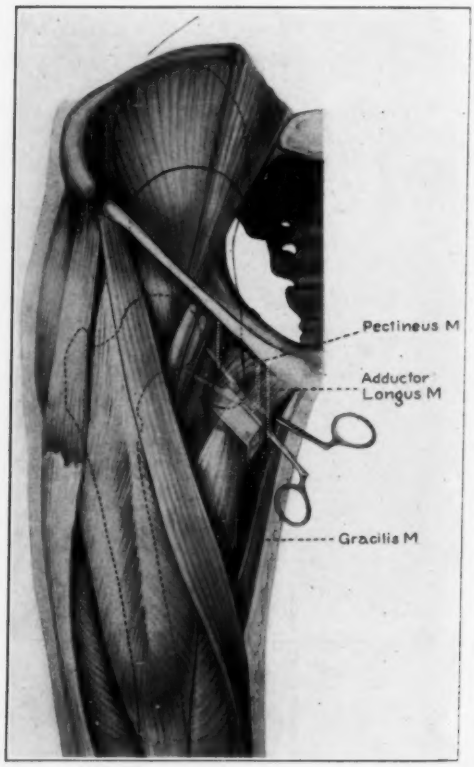


FIG. 3

Diagrammatic representation of a retroperitoneal abscess arising from the external iliac glands and dissecting downward on the surface of the iliopsoas muscle and thence mesially to the adductor region. Surgical approach to this abscess is shown extending beneath the adductor longus muscle. Superiorly, a second line of incision is shown for an unusually large abscess. It will be noted that the abscess is not in contact with the hip joint.

In a case in which there is a recognized pyarthrosis of the hip joint and a palpable fluctuant iliac abscess, the question naturally arises whether the hip-joint involvement is secondary to the lymph node or abscess infection. In the series of cases to be presented, the clinical evidence points to the hip joint as the primary seat of infection. No similar cases have been reported.

Seven cases of purulent infection of the hip joint, associated with inguinal lymphadenitis and iliac abscess, were encountered. In six of these cases, the right hip was involved. The age limits were from six

TABLE I

SUMMARY OF SEVEN CASES OF ACUTE PURULENT ARTHRITIS OF THE HIP JOINT WITH ASSOCIATED ILIAC ABSCESSES ARISING FROM SECONDARY INFECTION OF THE EXTERNAL ILIAC GLANDS

ETIOLOGY	
Otitis media or mastoiditis	5 cases
Trauma	1 case
Idiopathic	1 case
COMPLICATIONS	
Associated septicaemia (repeated positive blood cultures)	4 cases
THERAPY	
Immobilization:	
Without surgery	1 case
With surgery	6 cases
Drainage:	
Hip joint	
Anterolateral	2 cases
Anterolateral and posterior (Ober)	1 case
Supra-Poupart or abdominal	4 cases
Adductor or Ludloff incision	4 cases*
Combined adductor and abdominal	2 cases
AVERAGE DURATION OF INFECTION	
Before admission:	
Six days	5 cases
Sixty days	1 case
Ninety days	1 case
After admission:	
Seventy-five days	6 cases
One year	1 case
END RESULTS	
Ankylosis (without deformity)	3 cases*
Marked limitation of motion	3 cases
Good, useful motion	1 case

* Bilateral in one case.

years to fifteen years. All of the patients were white children,—four girls and three boys. Five of the patients had a preceding or existing right-sided otitis media. Of these five patients, three had a mastoiditis; and two of this latter group, a lateral sinus thrombosis. Of this group of five patients, four had a hemolytic streptococcus septicaemia, proved by more than two consecutive positive blood cultures. One of the seven patients had, according to the history, a secondarily infected vaccination. The seventh patient had a history of a severe blow in the left groin.

FIG. 4

Case 1. July 4, 1934. Roentgenogram of pelvis, including both hip joints and showing abduction and external rotation of the right hip joint. On careful inspection, a large soft-tissue shadow, a pelvic abscess, is seen displacing the intestinal outlines to the left. Also, the right femoral head is seen somewhat laterally displaced from the acetabulum by exudate.

FIG. 5

Case 1. July 20, 1934. Roentgenogram of pelvis, including both hip joints and showing extensive soft-tissue infiltration of the right thigh and subluxation of the right hip joint by intracapsular exudate.

FIG. 6

Case 1. September 17, 1934. Roentgenogram of pelvis, including both hip joints. Subluxation of the right hip joint has been reduced by skin traction. The shadow of the iliac abscess is no longer visible, the abscess having been drained by an adductor incision. Progressive changes are shown in the hip joint.

FIG. 7

Case 1. December 11, 1934. Roentgenogram of the pelvis, including both hip joints. End result of the infection of the right hip joint: active motion; flexion, 50 degrees to 170 degrees; active adduction, 35 degrees; and active abduction, 15 degrees.

With the exception of the third case, in which the right hip joint was first infected and at a much later period the left hip joint became involved, the seventh case represents the single involvement of the left hip joint.

On admission to the hospital all of these patients were critically ill. In only two instances, were the children admitted on the Orthopaedic Service,—the patient who had received the injury in the groin and the patient with a streptococcic septicaemia, who had had a recent otitis media. The other five patients were admitted either on the Otological, Pediatric, or Surgical Services, signifying that the more prominent findings were either the pelvic abscess or the mastoiditis. In retrospect, however, the histories and findings indicate that the hip lesions were present at the time of admission to the hospital. In one instance, drainage of the large pelvic abscess was performed by a general surgeon on the assumption that the lesion represented an appendiceal abscess. This statement is made, not in a critical manner, but to emphasize the difficulties of this diagnostic problem. A second case was operated on as a possible iliac osteomyelitis.

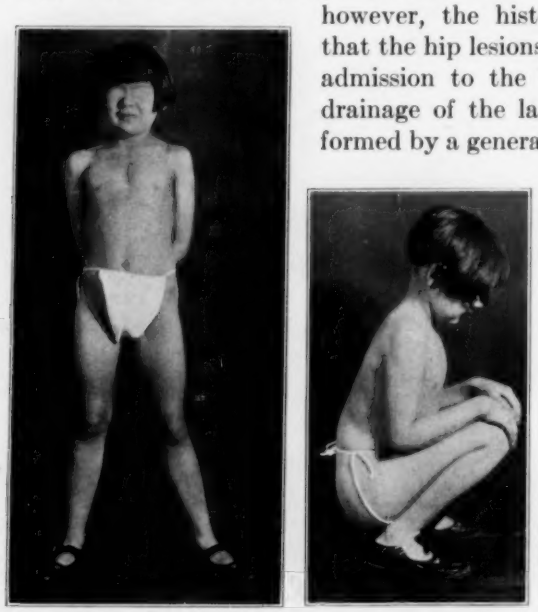


FIG. 8

Case 1. December 27, 1935. The operative wound is healed. For range of motion, see Fig. 7.

In only one of this series of seven cases was the hip lesion probably primarily osseous in origin, involving the cervical area. So far as could be determined, in the remaining six cases the lesions were presumably synovial in onset. All of the seven patients recovered.

The infecting organism was a hemolytic streptococcus in three cases, a non-hemolytic streptococcus in one case, a staphylococcus in two cases, and in the seventh case the bacterium was not recovered, although a pelvic abscess was palpated and aspirated.

With some few variations, the physical findings in this group of cases were the same. A feverish, sick child lay with the affected hip abducted, externally rotated, and flexed to about 90 degrees. In most instances, there was a visible fulness both above and below Poupart's ligament. On palpation of the hip joint, all motions were restricted by muscle spasm and accompanied by severe pain. In several instances, distention of the hip joint was palpable, but this was not invariably the

case. The inguinal glands were enlarged and prominent. Deep pressure immediately above Poupart's ligament and just above the anterior third of the iliac crest encountered a firm hemispherical mass, slightly tender. True fluctuation in this mass was occasionally discernible. Likewise, in several instances, simultaneous pressure over the iliac abscess and below the mesial third of Poupart's ligament elicited fluctuation.

From the preceding discussion, it has been noted that, whereas the description of the involved joint would have only one diagnostic suggestion to an orthopaedic surgeon—infected hip joint—other diagnoses may seem more likely to the pediatrician or the general surgeon because of the associated clinical picture. As in all instances of acute purulent infection of a joint, early roentgenograms show relatively slight abnormal changes, consisting primarily of soft-tissue involvement and possible cartilage destruction. In two cases in this series, the hip-joint involvement was not recognized until six weeks had elapsed following admission to the hospital. In the remaining five cases, the correct diagnosis was made in from one to seven days after admission.

On reviewing the roentgenograms, not only could some abnormality of the hip joint be seen in each instance, but likewise in most cases a soft-tissue shadow of the iliac abscess could be identified.

From the experience of treating this series and numerous additional cases of acute purulent infection of the hip joint with an unrecognized iliac abscess, it is concluded that the ideal therapeutic plan is as follows:

1. Complete and careful physical examination and roentgenographic examination to determine the site of infection with reference to localization of exudate accumulation.
2. General supportive therapy with emphasis on the administration of adequate fluids parenterally.
3. Application of skin traction to the affected leg.
4. Early blood culture. Subsequent multiple and frequent small blood transfusions if the blood culture is positive.
5. Aspiration of the hip joint to verify the diagnosis, followed by
6. Incision and drainage of the joint, the site of the incision to be determined by the chief site of pus collection
7. Incision and drainage of the pelvic abscess. The longitudinal incision of Ludloff on the mesial aspect of the thigh, extending between the adductor longus and gracilis muscles and bluntly either over or under the pectineus muscle, as indicated, to the abscess overlying the iliopsoas muscle. Drainage to be maintained by vaselin-gauze wicks. In those cases where the abscess presents anteriorly over the pectineus muscle immediately below Poupart's ligament, the incision may be made there, but hemorrhage from the great vessels is more likely at this site. If fluctuation or infiltration of the soft tissues is not felt in the adductor region of the thigh, the abscess of course had best be drained at the site of presentation, but preferably below Poupart's ligament.

Sometimes, in spite of changes in the hip joint, as seen in the roentgenogram, in the absence of pus in the joint, drainage of the iliac abscess alone may suffice. In the two cases in which the iliac abscess was drained above Poupart's ligament, faecal fistulae developed and healing was delayed until the adductor incision was made. Adequate emptying of the abscess did not follow supra-Poupart drainage. If the iliac abscess is very large, ideal drainage should consist of two incisions,—first, the adductor incision and, second, a three-inch oblique incision extending above the posterior iliac crest as in the incision utilized for ureteral inspection.

The hip-joint incision of choice is the posterior muscle-splitting incision of Ober. In some cases, however, the usual longitudinal anterolateral incision between the sartorius and vastus lateralis and the tensor fasciae femoris muscles may result in more direct drainage. In the case of a hip-joint abscess of extreme size, both of the incisions may expedite complete drainage.

In reviewing this series of seven cases of iliac abscess associated with purulent infection of the hip joint, the authors would again emphasize the difficulty of diagnosis. The general surgeon, as well as the orthopaedic surgeon, should learn to recognize this apparently unusual syndrome. Of especial significance is the association of these lesions with otitis media and mastoiditis. Two questions, so far unanswered, are offered for consideration. If in seven consecutive cases of purulent infection of the hip joint complicating iliac abscesses occurred, are these iliac abscesses frequent but unrecognized lesions? When exploring acute purulent infections of the joint for drainage, have iliac or prepsoas abscesses been unwittingly drained? It is conceivable, certainly, that an extracapsular iliac abscess may be unwittingly drained satisfactorily through a hip-joint incision, whether it be the posterior incision of Ober or the anterolateral incision, if the surgeon dissects through the joint capsule. Likewise, as in two cases of this series, although destructive in nature, the hip-joint infection may heal without drainage, if the iliac abscess has been adequately drained. In one case of this series, and in four cases without recognized iliac abscesses, satisfactory healing has occurred without surgical drainage, but with adequate and prolonged immobilization of the joint.

CONCLUSIONS

1. A secondary iliac abscess, arising from extension through the lymphatics to the external iliac glands, may be a relatively frequent complication of acute purulent infection of the hip joint.

2. This association of lesions presents a most difficult diagnostic problem in the acutely ill child.

3. Otitis media and mastoiditis are frequently associated with pyarthrosis of the hip joint.

4. The primary therapy of acute purulent infection of the hip joint should be general and supportive in type with immobilization of the extremity by traction.

5. Drainage of the iliac abscess accompanying hip-joint infection may best be accomplished in most cases by an adductor incision.

6. If immobilization is adequately applied and the patient is under close observation, surgical drainage of the hip joint may not be necessary.

7. The degree of function following acute purulent infection of the hip joint is variable, ranging from excellent motion to complete ankylosis.

8. The question is offered: Are pelvic abscesses frequent but previously unrecognized complications of acute purulent infection of the hip joint?

NOTE: Since writing this paper, one of the authors (J. A. F.) has operated on a child, nine months of age, with a very large left iliac abscess associated with an acute purulent infection of the left hip joint. This lesion was preceded by an acute retropharyngeal cellulitis. The blood cultures were negative. The child is recovering.

REFERENCES

1. ALIVISATOS, C. N.: Étude des lymphatiques de l'articulation de la hanche chez l'homme. Ann. d'Anat. Path., IX, 611, 1932.
2. CALDWELL, G. A.: Acute Suppurative Conditions of the Hip Joint. J. Am. Med. Assn., XCVIII, 37, 1932.
3. GRAVINGHOFF, W.: Säuglingskoxitis und retroperitonealer Drüsenabszess. Med. Welt, III, 1434, 1929.
4. GUTHRIE, DOUGLAS, AND MIDDLETON, D. S.: Septic Thrombosis of the Lateral Sinus in Children. With Report of a Case Complicated by Metastatic Infection of the Hip-Joint: Recovery after Seven Operations and Prolonged Illness. British Med. J., II, 141, 1931.
5. NATHAN, P. W.: Differential Diagnosis and the Treatment of Acute Osteomyelitis of the Upper End of the Femur, Involving the Hip Joint. Surg. Gynec. Obstet., LIV, 52, 1932.
6. SÁINZ DE AJA, E. A.: Coxitis estafilocócica como complicación de adenitis inguinalis. Clin. y Lab., XII, 301, 1928.
7. SLOWICK, F. A.: Purulent Infections of the Hip Joint. An Analysis of Sixty Cases. New England J. Med., CCXII, 672, 1935.

APOPHYSEAL SUBLUXATION

Disturbances in and about the Intervertebral Foramen Causing Back Pain

BY LEE A. HADLEY, M.D., SYRACUSE, NEW YORK

Various authors [1, 2, 7, 8, 9] have described two types of degeneration of the intervertebral disc. The degeneration observed in early life (Fig. 1) is characterized by herniation of the nucleus pulposus, either through a break in the cartilaginous plate into the adjacent vertebral body or through the annulus fibrosus into the spinal canal (Fig. 2). The latter condition may or may not produce symptoms by pressure upon the cord or nerve roots. The second type of degeneration, noted in later life (Fig. 3), is characterized by fragmentation of the cartilaginous plate with granulation tissue growing from the adjacent vertebral body into the disc. This portion of the disc later becomes replaced by fibrotic tissue.

These interesting pathological conditions of the disc are not of themselves painful. The pain and other symptoms result from secondary disturbances in the relationships between the adjacent structures. Jung and Brunschwig have described nerve endings as being present in the ligamentous tissue of the spine, but not in the disc.

Degeneration of the disc results in thinning of this structure, thus bringing the vertebral bodies closer together. If the posterior articulations do not slip past each other, a kyphos is produced at this level (Fig. 4), a condition usually encountered in the dorsal or upper lumbar region.

Thinning of the disc in the lower lumbar region usually produces a subluxation of the apophyseal or posterior articulations, resulting in the following possible causes of localized or referred pain:

1. Strain upon the ligamentous structures of the articulations.

2. A disturbance in the relationship between the articular surfaces. Due to the inclined plane of the posterior articulations, subluxation from thinning of the disc may thrust the lower vertebral body forward beneath the one above, so that the intervertebral foramen is decreased not only in its axial, but also in its anteroposterior diameter (Fig. 4).

3. Encroachment of the intervertebral foramen may produce a fibrosis about the bundles which make up the nerve root, giving rise to symptoms of radiculitis.

4. In extreme cases, the occurrence of actual bony impingement between the tip of the articular process and the pedicle above or the lamina below (Fig. 5) may cause pain. Such cases have already been reported by the author [5]. At first, the tip of the articular process presses against the periosteum-covered bony surface; later, notches may be eroded in the bone by this pressure (Fig. 6). The condition is best recognized in the stereoscopic 45-degree oblique view, which is frequently best made

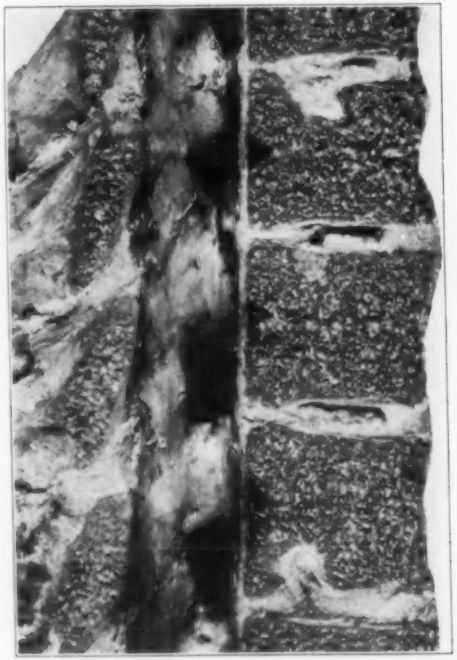


FIG. 1

The type of disc degeneration noted in early life is characterized by herniation of the nucleus pulposus into the bony substance of the adjacent vertebra through a break in the cartilaginous plate. This hernia may later become surrounded by a zone of sclerotic bone. Such a sclerotic area, sectioned tangentially, is seen in the upper portion of the middle vertebra. Cartilaginous plates are seen at the upper and lower limits of the two middle discs. Disc encroachment into the foramen behind the uppermost vertebral body has decreased the diameter of the foramen.

FIG. 2

Herniation of the fourth disc into the spinal canal, encroaching upon the lumen of the fourth intervertebral foramen. Compare the size of this foramen with that of the adjacent foramina. Section of the nerve root of this disc showed fibrosis about the nerve bundles as contrasted with a normal condition of the root of the fifth disc.

FIG. 3

The type of disc degeneration seen in later life is characterized by fragmentation of the cartilaginous plate, gradual fibrosis of the disc, and replacement of its substance by granulation tissue, blood vessels, connective tissue, and even bony trabeculae. Spur formation, limiting motion of these inadequate discs, takes place at their margins and is the result of a degenerative process, not of infection.

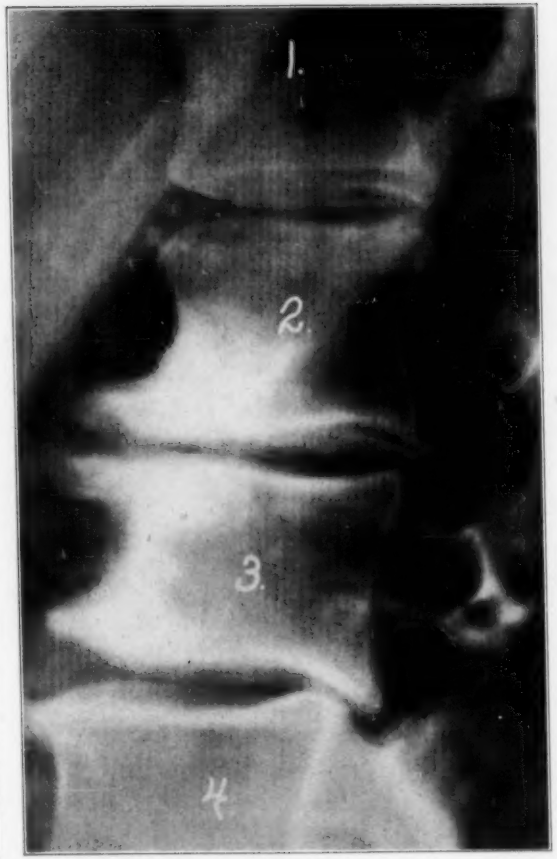


FIG. 4

FIG. 4

Roentgenogram (retouched). Thinning of the second disc has allowed the second and third bodies to approach each other. The posterior articulations have not subluxated, so that the second foramen remains normal in size and a lumbar kyphos has been produced at this level. Some degree of stabilization has been attempted by the spur formation. The third disc is also thinned, with the third and fourth bodies approaching each other. At this level, however, the posterior articulations have subluxated. Because of inclination of the plane of these joints, the fourth body has been wedged forward beneath the third. As a result, the third intervertebral foramen has become distorted in both the anteroposterior and longitudinal directions.

FIG. 5

FIG. 5

Oblique stereoscopic roentgenogram (retouched) made with the sagittal plane of the patient at an angle of 45 degrees to the horizontal plane. The third disc is normal; the fourth disc is thinned by an old herniation of the nucleus pulposus; sclerosis about this herniation is shown as a semicircle at *X*. Line *A* represents the normal interpedicular diameter of the third intervertebral foramen. *B* is the contracted interpedicular diameter of the fourth foramen. The normal third apophyseal (posterior) articulation is shown at *C*, but *D*, the fourth articulation, is subluxated, so that the superior articular process of the fifth body impinges against the pedicle of the fourth at *E* and the inferior articular process of the fourth body impinges against the lamina of the fifth at *F*. This patient had lumbar pain with unilateral muscle spasm of six months' duration, which was relieved after fifteen months of immobilization by plaster and a brace.

FIG. 6

Oblique view (retouched), showing thinning of the fourth disc with apophyseal subluxation and bony impingement. The superior articular process of the fifth body has eroded a notch into the under surface of the fourth pedicle, causing recurrent attacks of low-back pain, sciatica, and contralateral scoliosis of six years' duration.

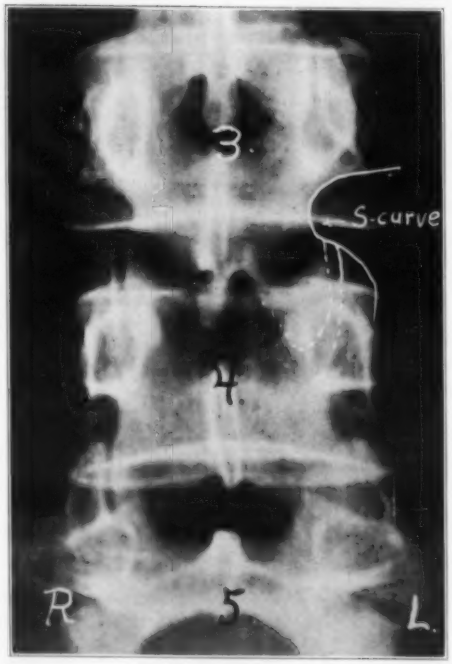


FIG. 7

Normal anteroposterior view (retouched), showing the S-curve which follows the under surface of the transverse process, the lateral surface of the inferior articular process, and extends straight across the apophyseal joint and thence along the lateral surface of the superior articular process from the body below. This curve can be seen in its normal condition between the third and fourth bodies on the right side and on both sides between the fourth and fifth vertebrae.

FIG. 8

Anteroposterior view (retouched), showing apophyseal subluxation with break in the S-curve where it crosses the joint, because the articular processes have slipped past each other. This is outlined between the third and fourth bodies on the right side, and the break in the continuity of the curve is easily visualized between the fourth and fifth bodies on both sides.

with the patient standing. It may also be recognized by a break in the S-curve as seen in the anteroposterior view.

DESCRIPTION OF THE S-CURVE

In the anteroposterior view, centering through an intervertebral disc of normal thickness in the lower lumbar region, an S-curve is formed, the line following the under surface of the transverse process and the lateral surface of the inferior articular process, and extending across the apophyseal joint and along the lateral surface of the superior articular process from the body below (Fig. 7). This curve is seen best if the plane of the articulation is nearly sagittal, but it can be made out even when the articulation is not in the sagittal plane. In case there is an apophyseal subluxation, with thinning of the disc, such a view shows a jog in the S-curve at the point where the posterior articulations have slid past each other (Fig. 8).

In certain cases of marked lordosis, some of the patient's weight is thrust posteriorly onto the posterior articulations of the spine, so that an apophyseal subluxation may take place.

In cases of scoliosis, there may be subluxation if sufficient rotation of the spinal bodies has not taken place; usually, however, even in extreme cases of scoliosis, apophyseal subluxation does not seem to be present if the bodies are rotated.

As a result of sprain or thinning of the anterior portion of the disc, reverse subluxation of the apophyseal joints may be visualized as a pulling apart of the articular processes.

SYMPTOMS

Among the clinical evidences of this condition may be noted tenderness to deep pressure, muscle spasm, and restricted motion with pain in the back. Referred symptoms may be those of radiculitis[4], the pain corresponding in distribution to that of the involved nerve root. The patient may complain of sciatica with disturbance of the reflexes, muscle atrophy, and Dejerine's sign,—that is, pain upon coughing or sneezing. There is usually, however, no pain upon pressure directly over the nerve; pain is present only when there is pressure over the nerve root. Homolateral or contralateral scoliosis may be present.

REFERENCES

1. Beadle, O. A.: The Intervertebral Discs. Observations on Their Normal and Morbid Anatomy in Relation to Certain Spinal Deformities. Medical Research Council, Special Report Series, No. 161, London, 1931.
2. Calvé, J., and Galland, M.: The Intervertebral Nucleus Pulposus. Its Anatomy, Its Physiology, Its Pathology. J. Bone and Joint Surg., XII, 555, July 1930.
3. Ghormley, R. K.: Low Back Pain. With Special Reference to the Articular Facets with Presentation of an Operative Procedure. J. Am. Med. Assn., CI, 1773, 1933.
4. Hadley, L. A.: Radiation Therapy of Radiculitis. New York State J. Med., XXXI, 1325, 1931.

5. HADLEY, L. A.: Subluxation of the Apophyseal Articulations with Bony Impingement as a Cause of Back Pain. Am. J. Roentgenol., XXXIII, 209, 1935.
6. JUNG, A., ET BRUNSCHWIG, A.: Recherches histologiques sur l'innervation des articulations des corps vertébraux. Presse Méd., XL, 316, 1932.
7. KEYES, D. C., AND COMPERE, E. L.: The Normal and Pathological Physiology of the Nucleus Pulposus of the Intervertebral Disc. An Anatomical, Clinical, and Experimental Study. J. Bone and Joint Surg., XIV, 897, Oct. 1932.
8. SASHIN, D.: Intervertebral Disc Extensions into the Vertebral Bodies and the Spinal Canal. Arch. Surg., XXII, 527, 1931.
9. SCHMORL, GEORG, UND JUNGHANNS, HERBERT: Die gesunde und kranke Wirbelsäule im Röntgenbild. Leipzig, Georg Thieme, 1932.
10. WILLIAMS, P. C., AND YGLESIAS, L.: Lumbosacral Facetectomy for Post-Fusion Persistent Sciatica. J. Bone and Joint Surg., XV, 579, July 1933.

THE PROBABLE ADAPTATION OF UTILITARIAN IMPLEMENTS FOR SURGICAL PROCEDURES BY THE "MOUND BUILDERS" OF EASTERN ARKANSAS *†

BY ELMER G. WAKEFIELD, M.D., ROCHESTER, MINNESOTA

Division of Medicine, The Mayo Clinic

AND SAMUEL C. DELLINGER, FAYETTEVILLE, ARKANSAS

Department of Zoölogy and Curator of the Museum, University of Arkansas

The adaptation of common utilitarian implements for surgical procedures by various people in ancient and in medieval times is a known historical fact. The first mention of the use of the cautery is in a case of an unidentified tumor of the breast, which was recorded in the ancient Egyptian literature[1]. The instrument employed in this case was the fire-stick or the fire-drill[2]. In the Fourth Dynasty of ancient China (2900 to 2750 B. C.), some sort of drill, probably metal, was employed for drilling a hole in the mandible to drain an abscess of a molar tooth. An Egyptian mandible belonging to the old kingdom (3000 to 2500 B. C.) was similarly drilled[3]. The successful use of these primitive boring and scraping implements of flint to relieve pain which was incident to the formation of an abscess undoubtedly led to an overenthusiasm and the development of metal instruments. In their description of the metal drills and knives, which were used for the purpose of cauterization, the medieval writers took it for granted that it was understood that these tools were adaptations of the early stone implements. Their high regard for the curative value of the cautery may be illustrated by a quotation from Hippocrates[4], who said: "I will give you a strong proof of the humidity of their constitutions. You will find the greater part of the Scythians, and all the Nomades, with marks of the cautery on their shoulders, arms, wrists, breasts, hip-joint, and loins, and that for no other reason but the humidity and flabbiness of their constitution, for they can neither strain with their bows, nor launch the javeline from their shoulder owing to their humidity and atony; but when they are burnt, much of the humidity in their joints is dried up, and they become better braced, better fed, and their joints get into a more suitable condition." The eighty-seventh aphorism of Hippocrates illustrates the high regard for the use of the cautery in his time: "Those diseases which medicines do not cure, iron cures; those which iron cannot cure, fire cures; and those which fire cannot cure, are to be reckoned wholly incurable." [5] Aretaeus, the Cappadocian, gave the following directions for the use of the cautery on the skull: "In the first place we must perforate the bone as far as the diploe, and then use cerates and cataplasms. . . . The exposed bones are

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to be perforated with the trepan if still any small portion prevent its spontaneous removal, . . . and when, having gone through the process of putrefaction and cleansing under the bold treatment of the physician, the wound comes to complete cicatrization, the patients escape from disease." [6]

The wide acceptance of these tools in medical practice no doubt was attributable to the fact that, when heated, they were effective in controlling the bleeding, which was a menace to the operator during the time he was at work. With the advent and use of sutures to control bleeding during the operation, the cautery lost much of its popularity.

It is a singular fact that the "Mound Builders" of Eastern Arkansas probably learned independently to utilize their own commonplace stone implements as cauteries, just as had been done by ancient Egyptians, Chinese, and Greeks. In the beginning, the "Mound Builders" may have first used the drill type of flint for opening abscesses. After the success thus obtained had been observed, a wider application of this and similar instruments was developed.

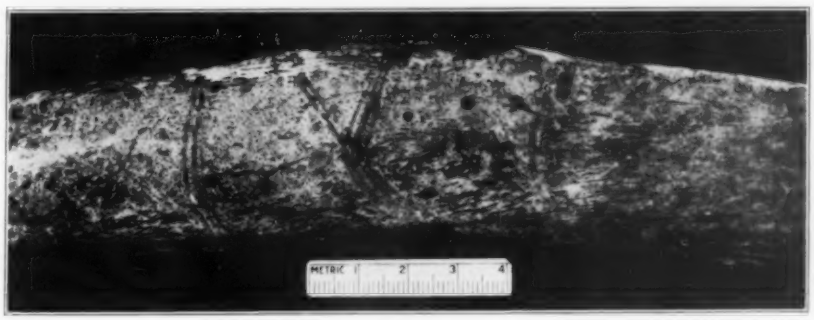


FIG. 1

Tibia with cautery markings.

In a review of the osseous remains of several hundred of these people, the grossly diseased specimens were studied. A number of the pathological specimens of long bones showed grooves which were angular to the long axis of the bone; in some instances, these grooves formed configurations similar to V, X, or Y (Fig. 1). These grooves gave definite evidence that they had been placed there before death, because healing had occurred. If these grooves had been the result of post-mortem marking, there would not have been any evidence of healing. It is known that, at times, the "Mound Builders" of the lower part of the Mississippi Valley denuded the bones of their dead and transported them varying distances for burial in one cache. If these were post-mortem markings which had been the result of some mortuary custom, the normal bones would have shown similar marks. No markings of any nature were found on normal bones. Further evidence to substantiate the idea that these were not the result of mortuary customs is the fact that the bones which were marked in this manner were obtained from fully extended remains, in

which all of the small bones of the hands and feet were in place. Collective remains usually consist only of the long bones, crania, and other large bones of the body.

The specimen shown in Figure 1 may be taken as an example of a number of diseased and injured tibiae which show such grooves or markings. Not a single normal appearing tibia in our collection was marked. In each case, these markings, which had been made with the cautery, almost without exception were placed on the medial aspect of the shaft of the bone, along its subcutaneous surface. The cauterization apparently was started at the anterior border and was extended posteriorly across the entire inner border of the bone. Where a bony prominence offered increased resistance to the posterior progress of the instrument, the groove was deeper anterior to the prominence than it was posterior to the prominence. The grooves were never made deep enough to enter the medullary portion of the bone.

The exception to the rule that cauterization was done only over the diseased portion of the bone was seen in one case. In this case, there was a punctured wound on the lateral aspect of the proximal third of the tibia; there undoubtedly had been a resulting osteomyelitis, with a draining sinus which had extended to the external surface. In this instance, the operator had cauterized the opposite border of the bone.

The femur was infrequently cauterized, and, when this operation

FIG. 2

Multiple trephining with cautery.

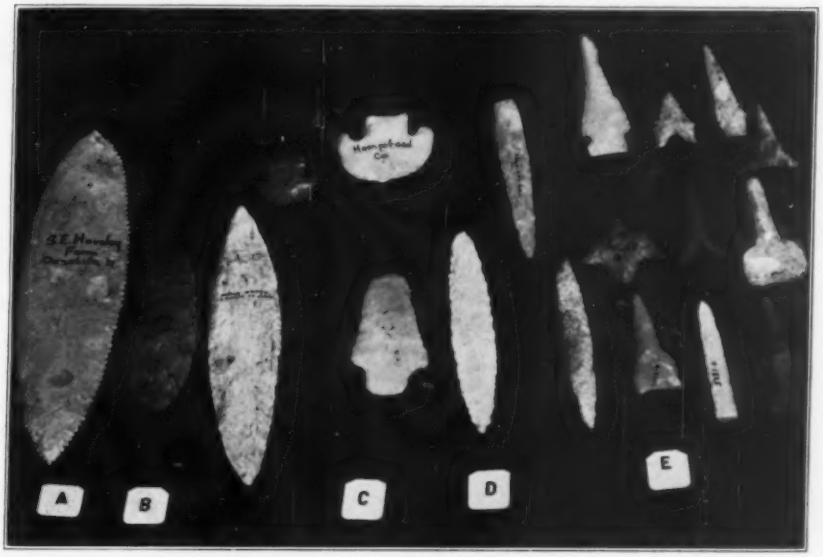


FIG. 3
Stone implements.

was performed on that bone, the cautery was applied to limited sections of the inner border of the distal third of the bone.

In a previous communication, we discussed two skulls which revealed irregular malformations and which we thought at the time might have been examples of trephinement with a cautery or a scraping instrument. Since we have become aware of the fact that some form of a cautery must have been used by these people, we believe that the perforations and scars, which were described and illustrated in our previous article, were the result of the cautery. A photograph of the best example of trephinement with the cautery in our collection is shown in Figure 2.

What were the implements used by these primitive, and now extinct, people for performing these operations? In Figure 3 are shown the stone implements that possibly could have served this purpose, because these people were devoid of metal implements or weapons; In Figure 3, *A* and *B* show types of serrated leaf-shaped knives, which could have been useful either for cutting or scraping bones. In fact, the cauterization of the tibia in Figure 1 was done with an instrument which had a serrated edge, since there are two parallel lines in each groove. Figure 3, *C* shows a type of instrument, commonly known as "blunts" or "scrapers", which would have been useful for scraping large surfaces, as was done in the case of the crania. Figure 3, *D* illustrates long lancelike weapons, which were beveled along the edges. These lances would be very effective instruments for cauterizing bones which were deeply situated. Figure 3, *E* represents a group of instruments which were known as drills or scrapers, and which usually have a haft. Some of them, which have sharp points and are more or less rotary in outline, would be effective

tools for puncturing abscesses or boring holes in bones. The other stones shown in this collection are flattened at the smaller end and have sharpened points, which would make them effective either as drills or scrapers.

COMMENT

In certain districts of Peru have been found many examples of trephinement by means of primitive boring and scraping instruments. Such practices were carried out by precolonial people as far north as Mexico. The use of the cautery and the use of boring or scraping instruments by the primitive people who lived within the continental limits of the United States has been thought to have been limited, if practised at all. We know of no reports of cautery marks, such as the marks which are described in this report, on the long bones of primitive people from any other part of the world. If the cautery had been similarly used for disease of long bones in any other part of the world, we could not give the "Mound Builders" credit for the originality of the idea, unless it could be proved that there had been no contacts between the two races. However, we feel that the adaptation of the primitive stone implements to surgical procedures was a natural consequence in America, as it was in ancient Egypt, Greece, and China.

SUMMARY

An improvised cautery (drills, knives, and scrapers) was used by the "Mound Builders" of Eastern Arkansas on long bones, jaws, and skulls. The indications for use of the cautery seem to have been definite organic disease of the bone, except in the case of trephinement of the skull. The cautery was applied directly to the most easily accessible portion of the affected region.

REFERENCES

1. The Edwin Smith Surgical Papyrus. Case Thirty-Nine. University of Chicago Oriental Publications. Vol. I, p. 363. Chicago, University of Chicago Press, 1930.
2. The Edwin Smith Surgical Papyrus. University of Chicago Oriental Publications. Vol. I, p. 365. Chicago, University of Chicago Press, 1930.
3. The Edwin Smith Surgical Papyrus. University of Chicago Oriental Publications. Vol. I, Plate 1. Chicago, University of Chicago Press, 1930.
4. Adams, Francis: The Genuine Works of Hippocrates. Vol. I, p. 214. London, The Seydenham Society, 1849.
5. Adams, Francis: The Genuine Works of Hippocrates. Vol. II, p. 774. London, The Seydenham Society, 1849.
6. Adams, Francis: The Extant Works of Aretaeus, the Cappadocian. p. 469. London, The Seydenham Society, 1856.

THE FATE OF TRANSPLANTED COW'S HORN

BY JOHN A. SIEGLING, M.D., AND JOHN J. FAHEY, M.D., CHICAGO, ILLINOIS

From the Division of Orthopaedic Surgery, Department of Surgery, University of Chicago

The use of foreign material for internal fixation of fresh or ununited fractures is a well-recognized procedure, but there are conflicting views in regard to the reaction of the tissues to and the ultimate fate of the material used.

Since Fabricious [8], in 1647, and Icart [8], in 1775, employed metal for suture in soft parts and bone, complications have frequently been observed from the use of non-absorbable material. In 1911, Lambotte [2] emphasized the frequency of complications in cases where metal plates had been employed, and stated that it was necessary later to remove them in 46 per cent. of the cases. In 1927, Dahl-Iversen [2] reported osteitis in 28 per cent. of 174 uncomplicated cases where Lane plates had been used. Many surgeons have reported similar discouraging results, where foreign material has been used in bone work, and there is a concensus of opinion that autogenous bone is the best material available for internal fixation. Laboratory workers and clinicians continue to search for material which will have the advantages of the autogenous graft without the necessity of removing bone from the same or another operative field.

Henderson [7] has used beef-bone screws with considerable success, and states that they are well tolerated by the bone, and are gradually but completely absorbed from within six months to a year. Experimental work [5] has demonstrated that boiled beef-bone pegs undergo gradual absorption and are replaced by new living bone.

Mish [1] of Russia is credited with being the first to use horn for internal fixation of fractures. He employed it in three cases, and suggested its general use. Lexer [1], in Germany, at approximately the same time stated that horn was wholly absorbable, non-irritating, and a stimulant to periosteal and endosteal growth. Nine successful cases were reported from his Clinic. In 1929, Dahl-Iversen [3] reported in the German literature his use of horn in the treatment of diaphyseal fractures. He was of the opinion that horn was absorbable and thought that because of this fact the common complications following the use of non-absorbable material would no longer occur. His later experimental work [4] failed to verify this early impression. He placed horn plates in slots made in the cortex across the side of a fracture and observed that the horn was not absorbed but became softer because of the influence of body temperature and fluids. The plates healed in place without reaction. In two cases, osteitis and fistula formation occurred subsequent to operation. At autopsy, in the cases that healed *per primum*, the horn plates were covered with connective tissue and situated in newly formed periosteal bone. There was no bone formation in the groove where the horn plate had contacted the shaft.

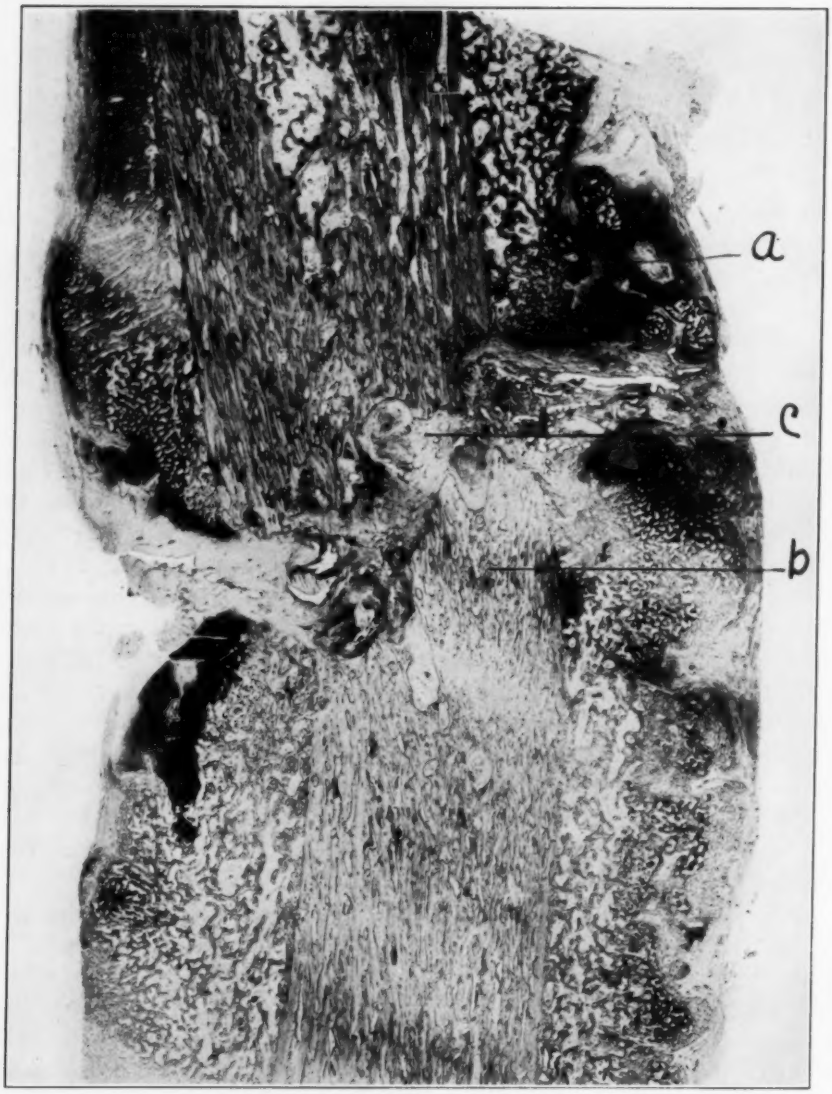


FIG. 1

Control fracture, six weeks after operation.
a: Callus undergoing ossification.
b: Necrotic bone.
c: Fibrous union.

Recently, in this country, the use of horn as a corticomedullary peg has been advocated by Fowler[6] as the method of choice in the treatment of fractures requiring internal fixation. He found experimentally that it underwent "considerable absorption in ninety days".

The lack of unanimity of opinion concerning the fate of horn led us to undertake an experimental study to determine the changes undergone by this tissue when transplanted.

FIG. 2

Fracture six weeks after operation in which horn was used as a corticomedullary graft.

a: Horn.
b: Line of fracture with fibrous union.
c: Fibrous tissue surrounding the horn.

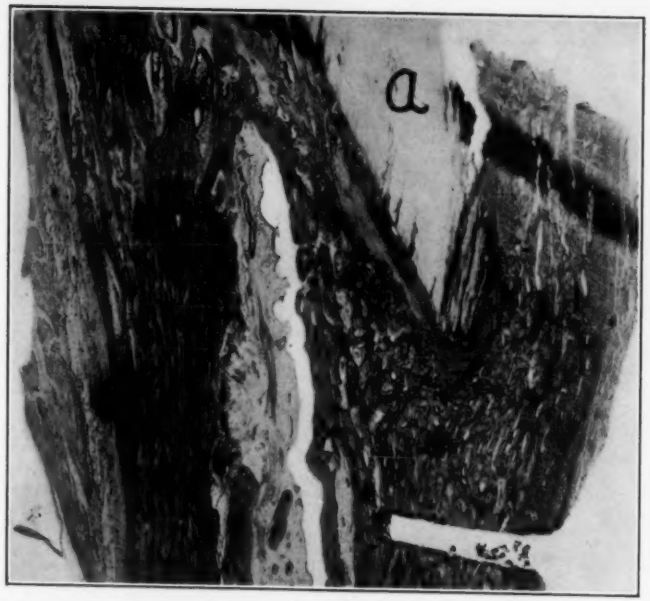


FIG. 3

Fig. 3: Horn transplant seven months after operation in which it was placed as a corticomedullary graft across the line of fracture.
a: Horn separated from the bone by dense fibrous tissue, with no attempt at ossification. Note the clearly defined edge of the horn.

FIG. 4

Fig. 4: Horn in medullary cavity of distal fragment seven months after transplantation.
a: Horn.
b: Fibrous tissue. Note the clear-cut borders of the horn.

The tibiae of dogs were exposed aseptically and fractured transversely in the mid-diaphyseal area. A cortical aperture was made about half an inch proximal to the fracture, and a section of cow's horn was passed through it into the medullary cavity, extending well across the line of fracture. The extremity was then immobilized in a plaster cast, which was allowed to remain in place for at least eight weeks, at which time it was removed. In three cases, a fistula developed at the site of the transplant, nine, ten, and thirteen weeks after healing *per primum*. In spite of the infection, the horn was found to be grossly unchanged when examined at necropsy. The remaining animals were sacrificed at intervals and autopsies were performed; the photomicrographs illustrate the condition of the horn transplants, six and thirty-one weeks after operation. In one experiment, both tibiae were fractured; horn was used for fixation in one leg, while the other was incorporated in plaster without internal fixation. Roentgenograms and gross findings at autopsy revealed no appreciable difference in the amount of callus present on the two sides.

The results of microscopic examination of the tissues are shown in the accompanying photomicrographs.

Figure 1, a section from the tibia of an animal six weeks after operation in which no horn fixation was used, shows callus undergoing ossification. The ends of the fragments show aseptic necrosis with moderate replacement of the dead bone. Lacunar absorption is noted and there is no continuity of bone either endosteally or periosteally.

Figure 2, a photomicrograph six weeks after operation in which horn was employed for fixation, shows a lesser amount of callus. The horn edges are clear-cut, and there is no evidence of absorption. The horn is surrounded by dense fibrous tissue which everywhere separates it from the bone. There is no tendency for the horn to ossify.

In Figures 3 and 4, photomicrographs seven and one-half months after operation, the horn edges are sharply defined, and there is little evidence of absorption and none of substitution of horn by bone. Dense fibrosis is again seen about the horn, separating it from the bone.

SUMMARY

Horn was used as a corticomedullary graft in experimental animals following open operation and fracture to determine its absorbability and its influence on bony union. Microscopic study of cases as late as seven and one-half months after operation revealed little, if any, evidence of absorption of the horn or stimulation of osteogenesis.

CONCLUSIONS

1. Cow's horn is relatively non-absorbable, and the tissues react to it as they would to other non-absorbable material.
2. Cow's horn appears not to stimulate osteogenesis.

REFERENCES

1. Boliarsky, N. N.: Cow's Horn as Plastic Material in Treating False Joints and Fractures. Vestnik Khir., IX, 244, 1927.
2. Dahl-Iversen, E.: On the Frequency and Duration of Ostitis after Osteosynthesis, Illustrated by 274 Cases and Re-Examination of 66 Cases of Operatively Treated Fractures. Acta Chir. Scandinavica, LXIII, 41, 1928.
3. Dahl-Iversen, E.: Osteosynthesis mit resorbierbarem Material. Arch. f. klin. Chir., CLVIII, 680, 1930.
4. Dahl-Iversen, E.: Experimentelle Untersuchungen über die Osteosynthesis mit resorbierbarem Material bei Kaninchen und Meerschweinchen. Arch. f. klin. Chir., CLXV, 345, 1931.
5. Davison, Charles, and Christopher, Frederick: The Use of Boiled Beef-Bone, Intramedullary Pegs in the Fractures of Long Bones. An Experimental Study. Surg. Gynec. Obstet., XXXVIII, 534, 1924.
6. Fowler, E. B.: Cow's Horn for Fixation of Fractures: Its Stimulating Effect on Callus Formation and a Simplified Technic. Illinois Med. J., LXVI, 231, 1934.
7. Henderson, M. S.: The Use of Beef-Bone Screws in Fractures and Bone Transplantation. J. Am. Med. Assn., LXXIV, 715, 1920.
8. Scudder, C. L.: The Treatment of Fractures. Ed. 10, p. 776. Philadelphia, W. B. Saunders Co., 1926.

GAIT AND MUSCLE FUNCTION RECORDED BY THE ELECTROBASOGRAPH

BY R. PLATO SCHWARTZ, M.D., OTTO TRAUTMANN, AND ARTHUR L. HEATH, ROCHESTER, NEW YORK

From the Department of Surgery, Division of Orthopaedics, Rochester University, School of Medicine and Dentistry, Rochester, New York

The first description of the electrobasograph was presented in November 1933[1]. Since then, this instrument has been used for making clinical records of gait at the Strong Memorial Hospital. Important experimental work has been conducted in cooperation with one of the large shoe manufacturing companies, and this cooperative effort has led to the accumulation of data pertaining to the functional requirements of shoes in relation to the foot in motion[2]. On the basis of these findings, fundamental changes were made in the design of lasts. The end results of these changes have, for the first time, been expressed in shoes to meet the requirement of balance of the foot in motion. Only through the use of the electrobasograph, was it possible to record imbalance accurately, and to interpret the changes in last design, essential for balance of the foot in association with the differences in heel height required for individual women[2].

More than 800 records of patients and "normal" individuals were made with this original electrobasograph, which was designed and constructed in the gait laboratory. By careful measurements of every line on each record, we have learned that these records were consistent; therefore, the instrument was dependable. Upon this premise, confidence was fostered in the electrobasographic method of recording human locomotion. Moreover, this experience encouraged us to make the improvements in the mechanism as herein described.

It was desirable to have: a greater precision in the instrument, a recorded definition of time in tenths of seconds, improvement in the facility and accuracy of the interpretation of records, and a greater economy in operation of the electrobasograph. The attainment of these indicated improvements was not possible with the limited facilities of our own laboratory.

Through the cooperation of one of the large optical companies, the construction of a precision instrument was begun in January 1933. The original electrobasograph was used as a model and the principles of operation were modified to make possible the improvements mentioned.

In design, this new instrument (Fig. 1) represents the maximum compactness consistent with the requirements enumerated. It was desirable that the records should be proportional to those produced by the original instrument. The present motor speed and the placement of the openings in the aperture plate meet this requirement.

For both convenience and economy of operation, the use of standard 35-millimeter motion-picture film was indicated. The Eastman positive film has been found to have the most suitable emulsion for producing the best records. Figure 2 illustrates an average record of "normal" gait on 35-millimeter motion-picture film. At the top of the film, there is a photographic record of the unit number, date, and the name of the patient; the diagnosis and other information may be added, if desired. The film may be moved forward manually as is necessary in making the photographic record of each legend.

It will be seen that the record has two sets of lines which are at right angles to each other. The lines parallel to the width of the film indicate time recorded in seconds and tenths of seconds. One second of time is indicated by the space between the heavy lines which are separated by ten equal spaces. The lines parallel to the length of the film are the recorded duration of weight-bearing on the respective points of the functional osseous tripod of each foot, as expressed through the medium of the subject's shoes.

These six lines are the result of the exposure of a photographic emulsion by light which passes through corresponding openings in the aperture plate. Three additional slits in the aperture plate were provided for recording muscle function, or the use of crutches, simultaneously with gait records. In brief, nine vertical lines may be recorded on the film.

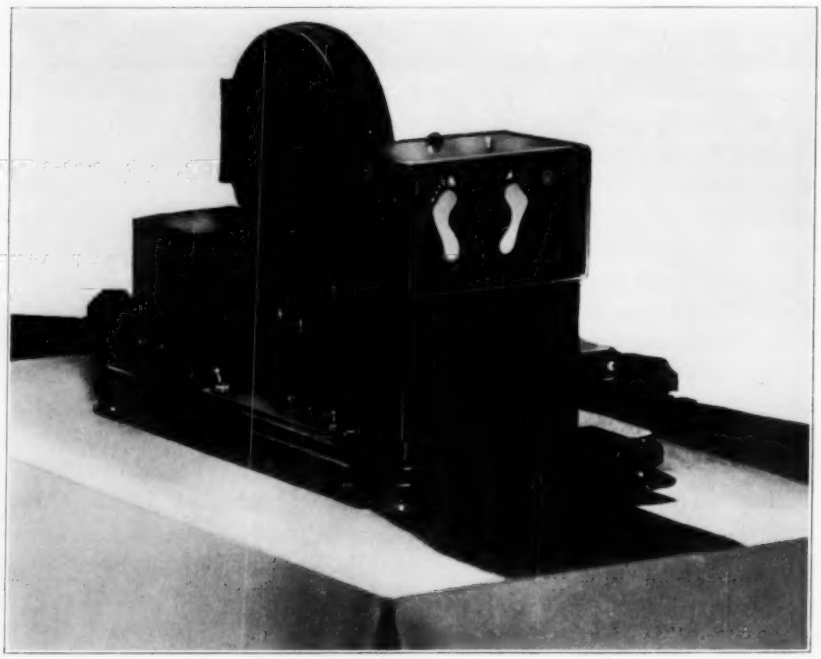


FIG. 1

The 35-millimeter electrobasograph which makes photographic records of the way a subject walks.

The timing in seconds and tenths of seconds is, therefore, applied to all alike. A sharp image of all lines recording gait, muscle function, etc., is assured by an adjustable-friction film gate which causes the film to be held straight at the aperture plate where exposure takes place.

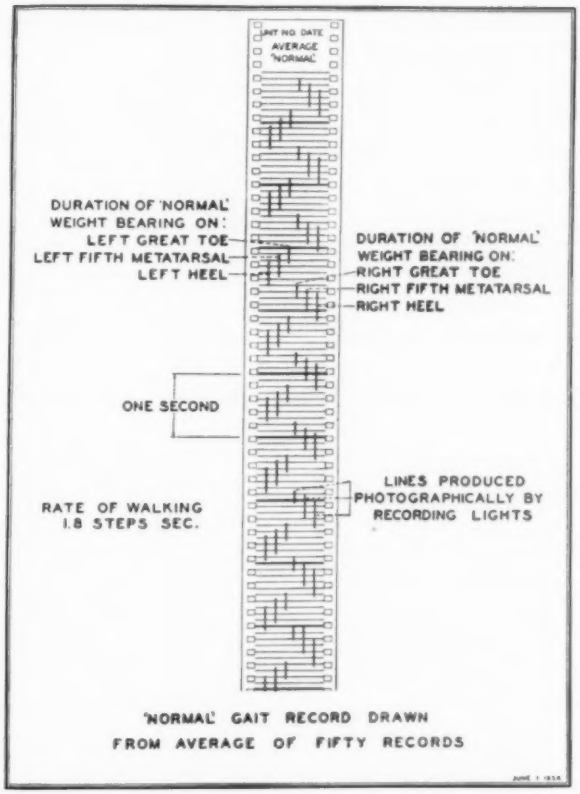

UNIT NO. DATE
AVERAGE 'NORMAL'
DURATION OF 'NORMAL' WEIGHT BEARING ON:
LEFT GREAT TOE
LEFT FIFTH METATARSAL
LEFT HEEL
DURATION OF 'NORMAL' WEIGHT BEARING ON:
RIGHT GREAT TOE
RIGHT FIFTH METATARSAL
RIGHT HEEL
ONE SECOND
LINES PRODUCED PHOTOGRAPHICALLY BY RECORDING LIGHTS
RATE OF WALKING 1.8 STEPS SEC.
'NORMAL' GAIT RECORD DRAWN FROM AVERAGE OF FIFTY RECORDS

FIG. 2

The method of making the record (Fig. 4) is identical with that described in the first paper which presented the electrobasograph. Reloading with new film is made easy by the automatic release of the film gate when the film chamber is opened. Rapid and accurate threading of the film has been made possible by backward rotation of the sprocket.

A special device is provided to notch the edges of the film at the end of each record, so that the records may be identified in the dark room for cutting before developing. An audible warning signal prevents the possibility of continuing to make records after all the unexposed film has been used. The total number of feet of film used in a given time is shown by the footage indicator which may be turned back to zero by a key. An additional feature provides for making a number of records up to twenty-five, after which they may be removed from the instrument in a light-proof chamber for developing. The intermittent illumination of a red light is a visual indication that the machine is in operation. Failure of illumination of any bulb in the instrument is instantly visible; thereby preventing errors. Moreover, all of

Name .....
Unit No. .....

Normal Weight-Bearing Time
Average Rate of 1.8 Steps Second

Date		
Record No.		
Left Heel	.444	
Left Met.	.525	
L. Gt. Toe	.541	
R. Gt. Toe	.540	
Right Met.	.502	
Right Heel	.469	
Time on L. Foot	.735	
Time on R. Foot	.668	
R. Toe-L. Heel Dbl. Wgt	.108	
L. Toe-R. Heel Dbl. Wgt	.101	
Steps Per Second		

FIG. 3

Showing record blank used in tabulating weight-bearing time. Figures given are the average of more than 1,000 records of "normal" individuals.

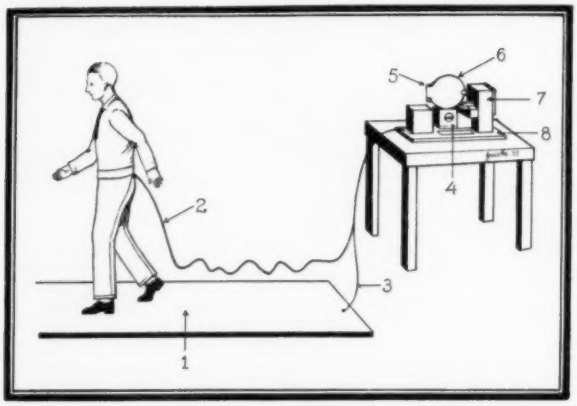


FIG. 4

Method of making records with the new 35-millimeter electrobasograph: *1*, metal surface on floor; *2*, wires from metal contacts on shoes; *3*, ground circuit; *4*, take-up film chamber; *5*, electrobasograph; *6*, film magazine; *7*, light magazine; *8*, base.

these lamps are readily accessible without the use of tools

The mechanical improvements enumerated were immediately reflected in the records produced by the new 35-millimeter electrobasograph. Greater convenience in handling and filing the records was made possible by their reduction to one-half the former size.

The foregoing description of the mechanism is essential to an understanding of the application of the 35-millimeter electrobasograph to the study of human locomotion. Without this knowledge, one cannot adequately grasp the significance of records revealing the correlation of gait and the function of the muscles which control the foot.

Our present knowledge of muscle function is based upon the mechanics of related structures, as observed in the cadaver, or by the behavior of a member under the influence of the voluntary contraction of one or more muscles. Such studies are either purely mechanical, as related to an inanimate object, or they are static observations of the interrelated muscle function which makes it possible for a person to walk. For these reasons, it is believed that the essential knowledge relevant to muscle function in relation to gait has not been provided by such methods of study.

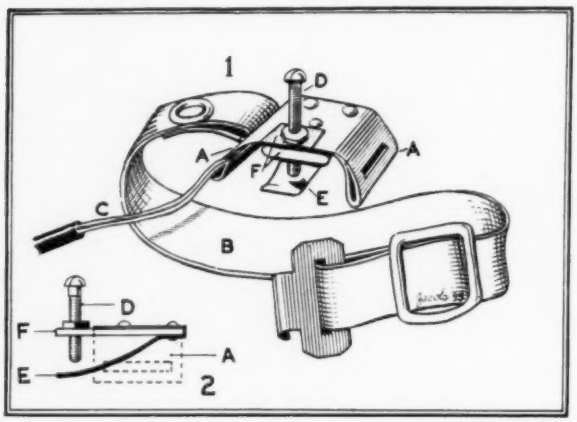


FIG. 5

A contact for recording muscle function (usefulness not defined beyond the limits expressed in this paper): *A*, flanges; *B*, adjustable-tension rubber band with clip for flange; *F*, base through which adjustable screw *D* passes; *E* spring which, when elevated by tendon, contacts screw *D* and completes circuit which is carried to lamp in electrobasograph by wires *C*.

It was, therefore, indicated that an effort

should be made to record muscle function in terms of duration and sequence of contraction during the act of normal walking. Moreover, it was desirable to proceed in a manner which would accurately correlate the duration of muscular contraction with the established "normal" gait record.

Accordingly, our first thoughts were directed to the development of a method that would provide the required data with reference to major muscles which control the function of the foot during the act of walking. The following procedure was, therefore, carried out with respect to the tibialis anterior, the peronei, the gastrocnemius and soleus, the extensor digitorum communis, and tibialis posterior. The tendons of these respective muscles were used as the medium for determining the sequence and duration of contraction as related to the sequence of weight-bearing of the respective functional areas of each foot, as compared with the normal sequence of weight-bearing.

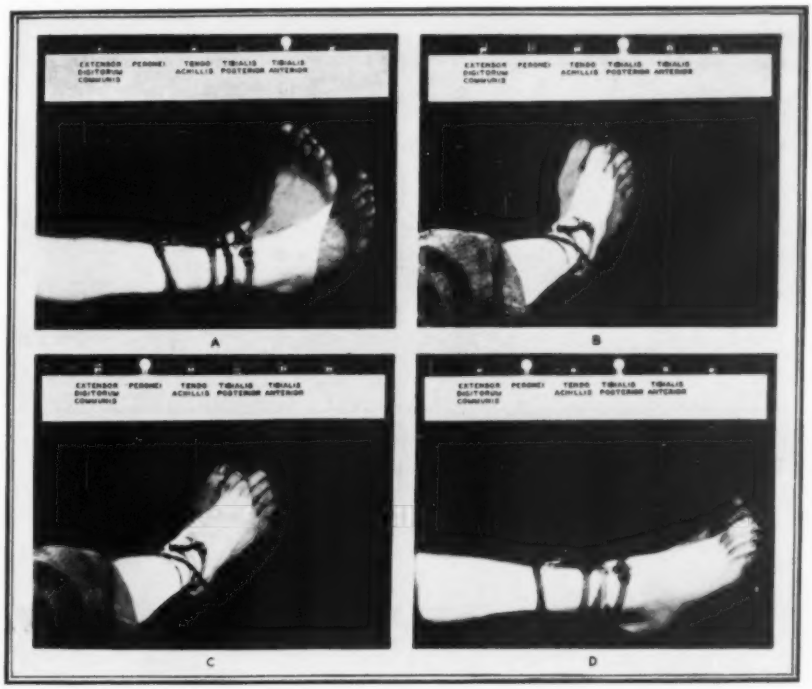


FIG. 6

Showing contacts placed over the tendons.

A: From the neutral position, the foot was dorsiflexed and the forefoot held in varus by contraction of only the tibialis anterior.

B: Heel in varus, forefoot neutral, by voluntary contraction of only the tibialis posterior.

C: Heel and forefoot in valgus, from neutral position by voluntary contraction of only the peronei.

D: Foot in plantar flexion, from neutral position, by an equal degree of voluntary contraction of both the tibialis posterior and the peronei.

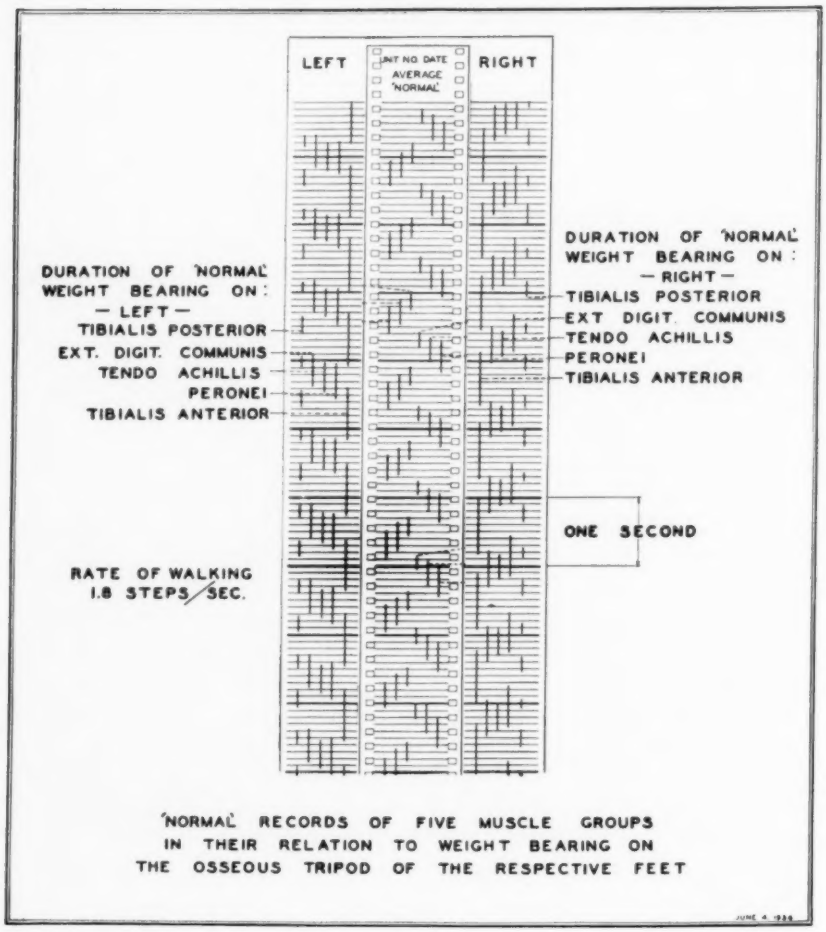


FIG. 7

These records reveal the rhythm in sequence and duration of contraction of the respective normal muscles in relation to the duration of weight-bearing on the respective functional areas of each foot during the act of "normal" walking at the rate of 1.8 steps per second.

It is evident that the method required a mechanism upon which the influence of the contracting muscle would, through the elevation of its tendon, activate an incandescent lamp. Repeated experiments led to the design of such a mechanism as is illustrated in Figure 5. The flanges (*A*) elevate the spring (*E*) above the surface overlying the tendon. The elastic band (*B*) is adjustable for tension sufficient to hold the mechanism in fixed position, lateral displacement being prevented by the flanges (*A*).

A number of such contacts were simultaneously placed over the respective tendons as shown in Figure 6. No bulbs were illuminated when the foot rested in the neutral position. Voluntary contraction of only the tibialis anterior (Fig. 6, *A*) held the foot in dorsiflexion with varus of the forefoot. This caused illumination of only the corresponding bulb as il-

lustrated. Voluntary contraction of only the tibialis posterior changed the neutral position of the foot to one of varus without dorsiflexion. This was accompanied by illumination of only the corresponding bulb (Fig. 6, *B*). Isolated voluntary contraction of the peronei held the foot in valgus without dorsiflexion of the forefoot (Fig. 6, *C*). Simultaneous voluntary contraction of the tibialis posterior and the peronei changed the neutral position of the foot to one of plantar flexion. Both corresponding bulbs were illuminated (Fig. 6, *D*). Similar experiments were made to reveal the contraction of the extensor digitorum communis.

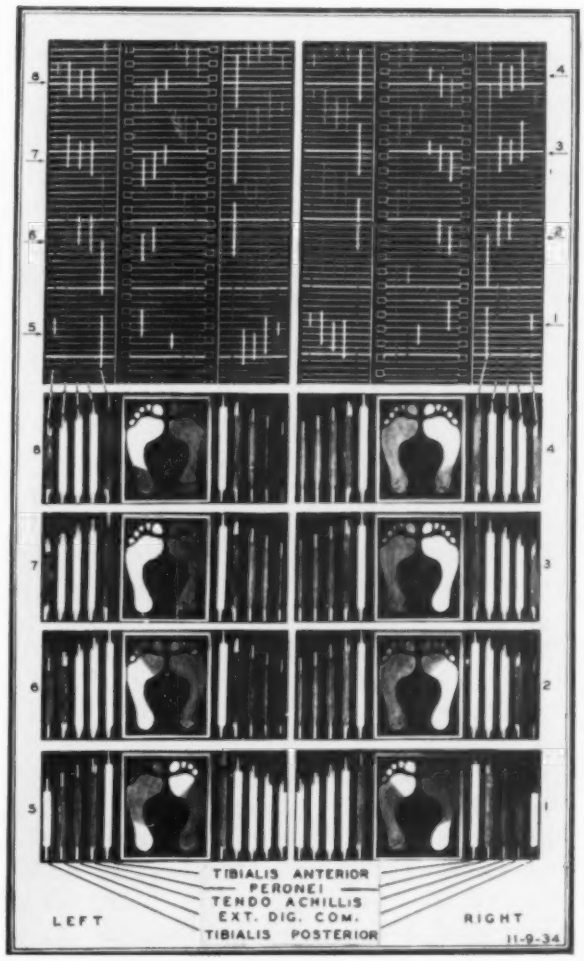


FIG. 8

The visualization of muscle function in eight phases of a single step, correlated with the sequence of weight-bearing on the respective functional areas of each foot.

Such evidence of the contraction of the gastrocnemius and soleus could not be obtained with the non-weight-bearing foot. Plantar flexion is apparently initiated by the tibialis posterior and the peronei. Evidence thus far indicates that contraction of the gastrocnemius and soleus follows under the influence of superincumbent weight. *It is, therefore, evident that these experiments proved the absence of a current except when the circuit was closed by the elevation of a tendon due to the contraction of one or more muscles.*

This having been determined, records of muscle function were then made simultaneously with records of gait. The procedure for making the electrobasographic gait records was the same as has been described in papers previously published. In addition, the following method was applied for recording the sequence and duration of contraction of the muscles in successive normal individuals while walking.

The muscle contacts were placed over the right and left tibialis anterior muscles respectively. Repeated tests were made to prove that the contact was closed only when the tendon was elevated by contraction of the respective muscles. Under these conditions, several records were made of the same and different normal individuals during the act of walking. This procedure was repeated with respect to the other four muscles mentioned. The sequence and duration of muscle contraction were finally determined by averaging the records made on each muscle in relation to the average rate of walking, as determined by the gait record of each person.

The rhythm in sequence and duration of contraction of these muscles in relation to the duration of weight-bearing time on the three functional divisions of each foot is revealed in Figure 7. A complete mathematical expression of the records of muscle function is in preparation. A subsequent paper will correlate this with the normal gait record.

A better understanding of Figure 7 may be gained by a study of Figure 8. This illustration was made by interpreting Figure 7 in terms of eight phases of a single step, as indicated in the upper portion from right to left. For visualization and ease of understanding, a section, including one step and the corresponding muscle function, was accurately copied from the record. This section of the record was fixed on a circular drum which was driven by an electric motor. This drum was mechanically and electrically connected with a transillumination box which was wired with electric bulbs in compartments corresponding to the heel, midfoot, and forefoot of each foot. Glass tubes, fitted with electric bulbs, were arranged to represent the five muscles in the order named. The sequence and duration of illumination of each set of bulbs in this entire mechanism was activated by the record on the revolving drum. The rate of rotation of this drum was made variable by rheostat control; it could be stopped by a switch at any phase of the step. It was, therefore, possible to make photographs of eight successive phases of a single step, with relation to weight-bearing on the three major functional areas of each foot. By so doing, we were able to reveal the muscles which were contracting in each respective phase of the step. The visualization of such muscle function was, therefore, made with relation to the sequence of weight-bearing on each foot.

The plantar surface, as revealed by the divisions corresponding to the functional areas of each foot, is represented on the transillumination box, illustrated in the lower portion of Figure 8. The glass tubes, representing the five muscles, are arranged on the right and left sides of the transillumination box. The record of combined gait and muscle function is shown in the upper portion of Figure 8. This is a diagrammatic arrangement to reveal eight phases of a single step.

The period of double weight-bearing is revealed in Phase 1. Weight is being transferred from the left forefoot to the right heel. All muscles of the left leg are contracting except the tibialis anterior. On the right,

only the tibialis anterior and tibialis posterior are in contraction. Evidence of contraction of the tibialis posterior at this phase of the step accounts for the common observation of wear on the shoe heel, lateral to the midline. The arrow in Phase 1 of the gait record indicates a line which passes through the point of double weight-bearing on the left forefoot and the right heel. It will be seen that this line also passes through the lines indicating the contraction of the muscles mentioned.

In Phase 2, the left foot has entered the swing phase. Here it is normally held in dorsiflexion by contraction of the tibialis anterior. The right foot has received weight from the heel onto the area corresponding to the midtarsal region. The right tibialis anterior, the peronei, and the tendo achillis are in contraction; the contraction of the tibialis posterior has ceased. Referring to the gait record, a line passing through Phase 2 at the level of the arrow crosses the lines indicating weight-bearing on the right heel and midtarsal areas. It also crosses the lines indicating contraction of the tibialis anterior, the gastrocnemius-soleus (tendo achillis), and the peronei. This line passes through only the line indicating contraction of the left tibialis anterior, the left foot being in the swing phase.

In Phase 3, weight has been transmitted forward so that the entire plantar surface of the right foot is under the influence of superincumbent weight. Contraction of the peronei, the gastrocnemius-soleus (tendo achillis), and the extensor digitorum communis is indicated by the illumination of the tubes. The right tibialis posterior muscle is not in contraction. The left foot is still in the swing phase. The left tibialis anterior alone is in contraction.

Phase 4 finds the left foot still in the non-weight-bearing position under the influence of the contraction of only the tibialis anterior which holds it in dorsiflexion. The left forefoot is still held in varus as it swings forward. It is at this phase that the foot is being lowered prior to the reception of weight on the left heel in the next phase of the step. The right foot reveals elevation of the heel with transference of the full body weight onto the midtarsal and forefoot areas, principally the latter. This change has occurred under the influence of the continuation of the contraction of the right peronei, the tendo achillis, and the extensor digitorum communis. The gastrocnemius and soleus through the tendo achillis have exerted the maximum effort in the elevation of the heel under the influence of the entire body weight. The peronei and the extensor digitorum communis have effected a position of valgus of the foot which is essential for normal transference of the weight from the lateral to the medial side of the forefoot. In addition to this, the extensor digitorum communis has served the principal function of opposing plantar flexion of the toes in this phase of the step.

Phase 5 reestablishes the period of double weight-bearing. Weight is being transferred from the right great toe to the left heel. The phenomena relevant to contracting muscles are the same as described for the first phase, except that they are reversed to opposite sides.

In Phases 6, 7, and 8, the facts are the same as related for Phases 2, 3, and 4, except that all functioning structures are reversed to the opposite sides.

SUMMARY

1. The sequence and duration of contraction of the tibialis anterior, the peronei, the gastrocnemius and soleus (tendo achillis), the extensor digitorum communis, and tibialis posterior have been recorded during the act of walking.

2. All records have been timed accurately to within hundredths of a second.

3. With this precision, the records of muscle function have been simultaneously correlated with the sequence and duration of the weight-bearing areas of the feet during the act of walking.

4. The record of "normal" gait presented herewith is based upon the results obtained from the making of more than 1,000 records of human locomotion by the electrobasographic method.

The 35-millimeter electrobasograph was provided through the cooperation of Mr. Herbert Eisenhart. Continuation of the association with Mr. William Washburn has made possible the further work, reported herein, on requirements of the shoe in relation to the foot in motion.

REFERENCES

1. Schwartz, R. P., Heath, A. L., and Wright, J. N.: Electrobasographic Method of Recording Gait. Arch. Surg., XXVII, 926, 1933.
2. Schwartz, R. P., Heath, A. L., and Misiek, William: The Influence of the Shoe on Gait as Recorded by the Electrobasograph and Slow-Motion Moving Pictures. J. Bone and Joint Surg., XVII, 406, Apr. 1935.

A METHOD FOR MEASURING AND RECORDING JOINT FUNCTION

From the Fracture Clinic of the Massachusetts General Hospital

BY EDWIN F. CAVE, M.D. AND SUMNER M. ROBERTS, M.D.,
BOSTON, MASSACHUSETTS

Committee on Joint Measurement

When the Fracture Clinic at the Massachusetts General Hospital began end-result studies, the need of a standard system of measurement of joint function became evident. Fractures lend themselves well to a follow-up system, because their end results can be rated not only functionally, but anatomically and economically as well.

Individual methods of measuring and recording joint function vary considerably and, when grouped together, may be confusing. Therefore, to be of value, records must be uniform and all members of a clinic should use the same nomenclature when recording their findings.

This system has been made as simple as possible and does not pretend to cover the finer details of joint measurement. It is the result of ten years' trial, plus helpful suggestions received from twenty-five members of the Fracture Committee of the American College of Surgeons to whom this method was submitted for comment.

We hope that this outline will prove useful and, if adopted, will simplify the comparison of statistics compiled by different clinics.

GENERAL PRINCIPLES

1. All motions should be measured by degrees from a neutral point of zero.

2. The neutral point from which the motion is measured must be defined.

3. It is always worth while to mention the comparative motions in the joint of the opposite limb.

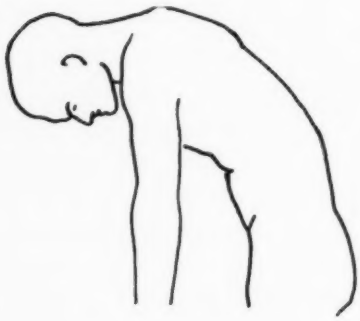
4. Angles should be measured with a goniometer or protractor.

5. Motions of joints above and below the affected part should be measured.

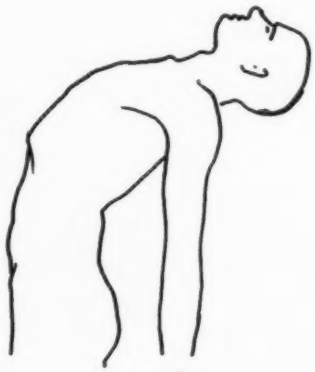
SPINE

Neutral position cannot be defined.

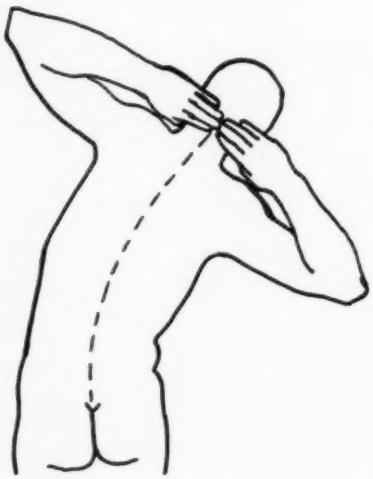
1. Forward bending—this motion cannot be measured accurately in degrees, but should be compared with the probable normal for the age of the patient. It should be noted whether the lumbar spine flattens or reverses itself. Motions should be carried out in both sitting and standing positions.
2. Extension—it should be noted to what degree the dorsal and lumbar curves change.
3. Lateral bending—right and left.
4. Rotation with pelvis fixed—right and left, comparing angle made by the shoulders with pelvis.



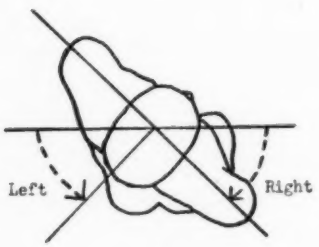
1
Forward Bending



2
Extension



3
Lateral Bending



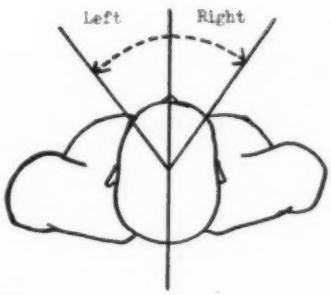
4
Rotation

NECK

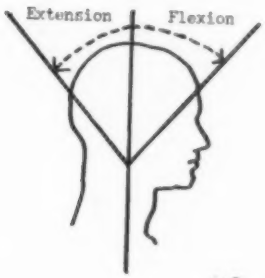
Neutral position is with head up and chin in.

1. Rotation—right and left.
2. Flexion.
3. Extension.
4. Lateral bending—right and left.

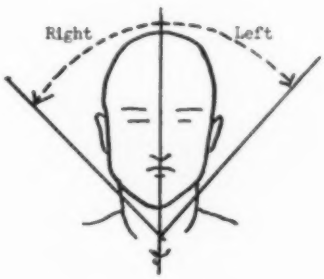
Neutral



1
Rotation



2+3
Flexion
and
Extension

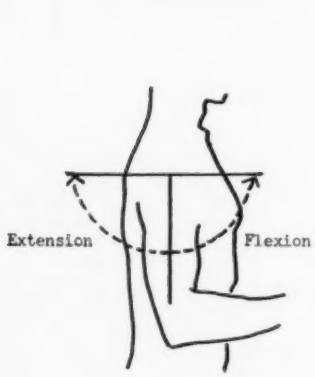


4
Lateral Bending

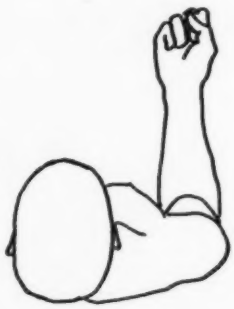
SHOULDER

Neutral position is arm to side, elbow flexed to 90 degrees, forearm pointing forward.

1. Flexion.
2. Extension.
3. Abduction—maximum 90 degrees.
4. Rotation in abduction.
5. Rotation in neutral (arm behind back to test extreme internal rotation—compared with opposite side).
6. Elevation—compared with opposite side and measured in number of degrees. (This is shoulder-girdle motion as compared with items 1 to 5 which are true humeroscapular motions.)

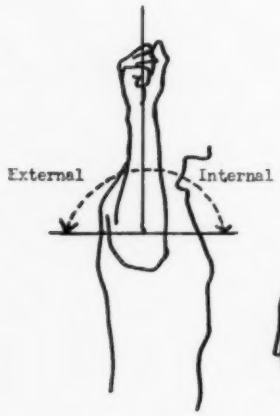


1 + 2
Flexion and Extension

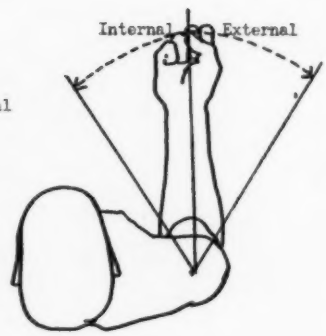


Neutral

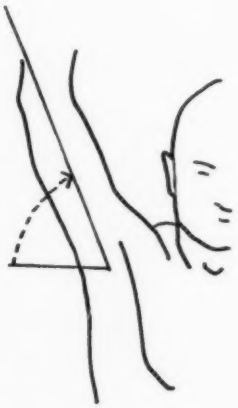
3
Abduction



4
Rotation in Abduction



5
Rotation in Neutral



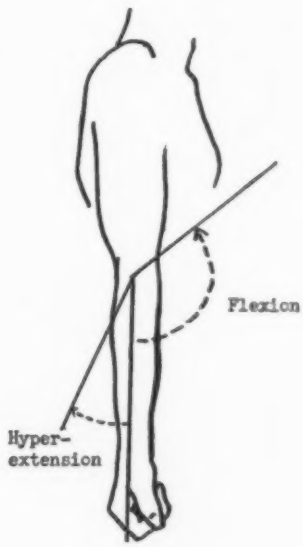
6
Elevation

ELBOW

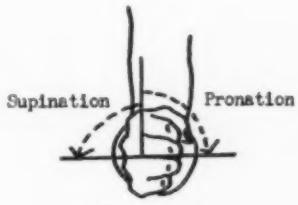
Neutral position is with forearm in extension.

1. Flexion—measured from complete extension, the neutral point.
2. Hyperextension—measured in degrees as compared with the opposite elbow.
3. Supination from a neutral point—which is midposition between pronation and supination.
4. Pronation—elbow must be fixed at side in 90 degrees of flexion.
5. When there is loss of complete extension, this loss should be recorded in degrees of permanent flexion.

Neutral



1 + 2
Flexion and Hyper-extension



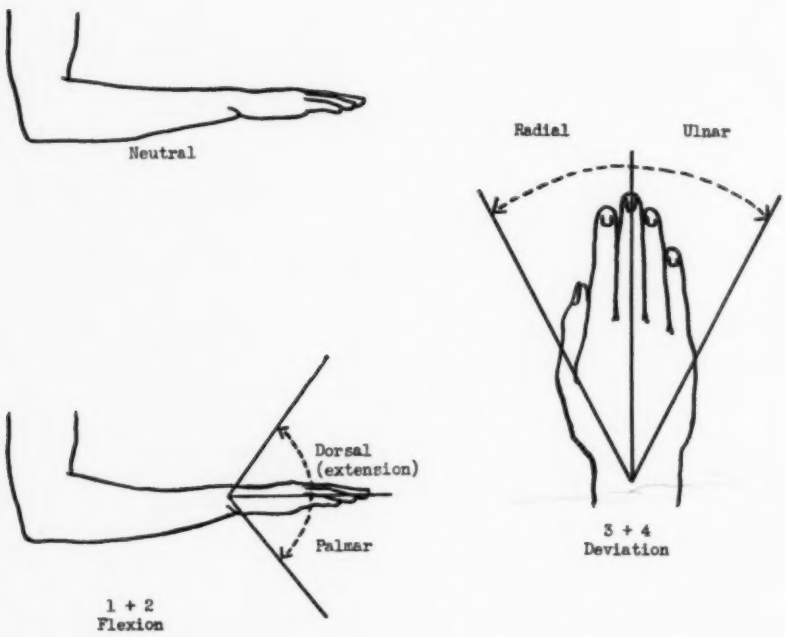
3 + 4
Supination and Pronation

WRIST

Neutral position is with hand in line with forearm with palm down.

1. Dorsiflexion (extension).
2. Palmar flexion.
3. Ulnar deviation.
4. Radial deviation.
5. Pronation
6. Supination

} to be noted as described under ELBOW.

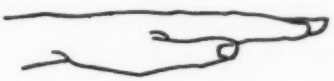


FINGERS

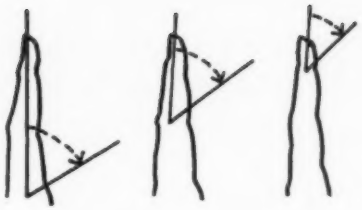
Neutral position is with fingers in extension.

1. All motions are in flexion either in the metacarpophalangeal or interphalangeal joints.
2. Hyperextension should be noted if present.
3. Test should be made for increased lateral mobility.

FINGERS



Neutral



1
Flexion

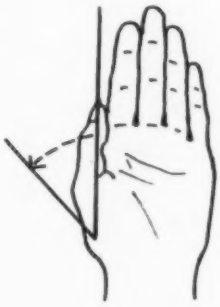
2
Hyperextension

THUMB

Neutral position is with thumb alongside the forefinger and extended.

1. Abduction—measured by the angle that the thumb makes with the forefinger.
2. Flexion—measured the same as for the fingers.
3. Opposition—cannot be measured in degrees; it should be noted how far thumb comes across the palm.

Neutral



1
Abduction

3
Opposition

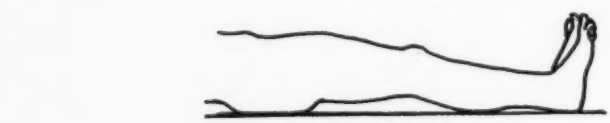
HIP

Neutral position is with hip in extension, patella pointing upward.

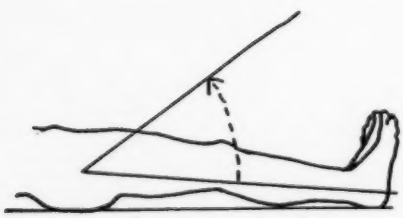
1. Flexion measured with the knee bent. Opposite thigh must remain in neutral.

1-A. To test permanent flexion, the opposite thigh must be flexed, so as to flatten the lumbar spine and to fix the pelvis.

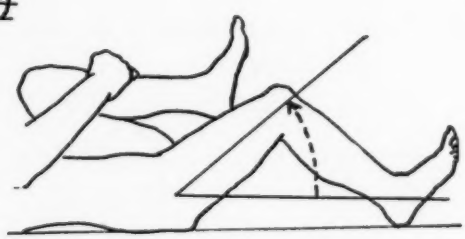
2. Hyperextension—neutral, the same as for flexion, but with the patient lying prone with opposite thigh over the end of table at an angle of 90 degrees.



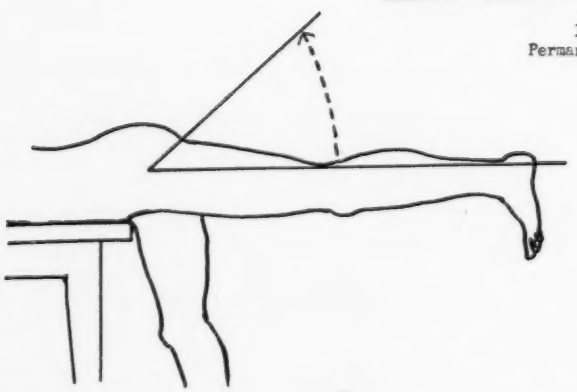
Neutral



1
Flexion



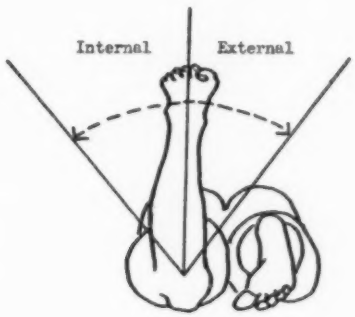
1 A
Permanent Flexion



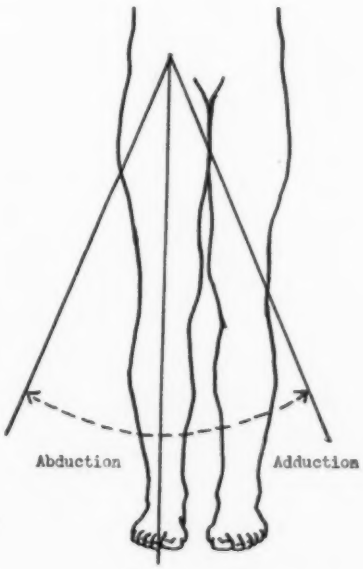
2
Hyperextension

HIP (*Continued*)

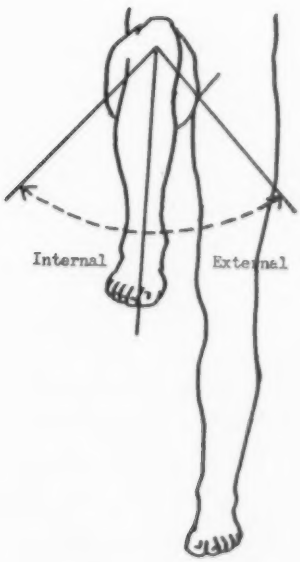
3. Abduction—measured from a line which forms an angle of 90 degrees with a line joining the anterior-superior spines.
4. Adduction—the same.
5. Rotation (external and internal) in extension. Measurement should be made with patient prone and knee flexed to 90 degrees.
6. Rotation (external and internal) in flexion. Measurement should be made with patient on back with knee and thigh flexed to 90 degrees.



5
Rotation in
Extension



3 + 4
Abduction and Adduction



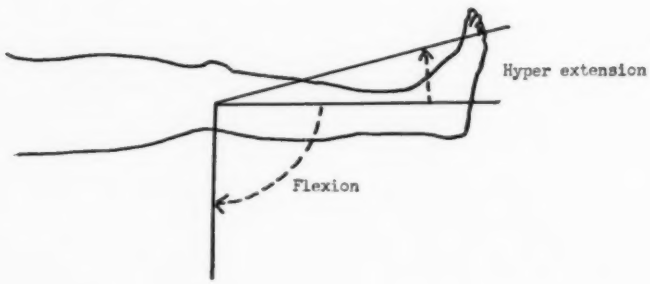
6
Rotation in flexion

KNEE

Neutral position is complete extension.

1. Flexion—measured in degrees from complete extension.
2. Hyperextension.
3. Anteroposterior stability should be tested with the knee in 90 degrees of flexion.
   Lateral stability should be tested with the knee in complete extension.
4. When there is loss of complete extension, it should be recorded in degrees of permanent flexion.

Neutral



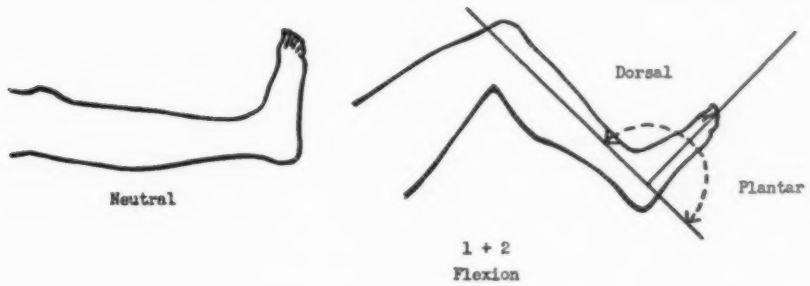
1 + 2
Flexion and Hyperextension

ANKLE

Neutral position is with the outer border of the foot at 90 degrees with the leg and in neutral as regards inversion and eversion.

1. Dorsiflexion should be tested with the foot in inversion.
   Measurements should be compared with knee flexed and with knee in extension, to rule out tight calf muscles.
2. Plantar flexion.

ANKLE



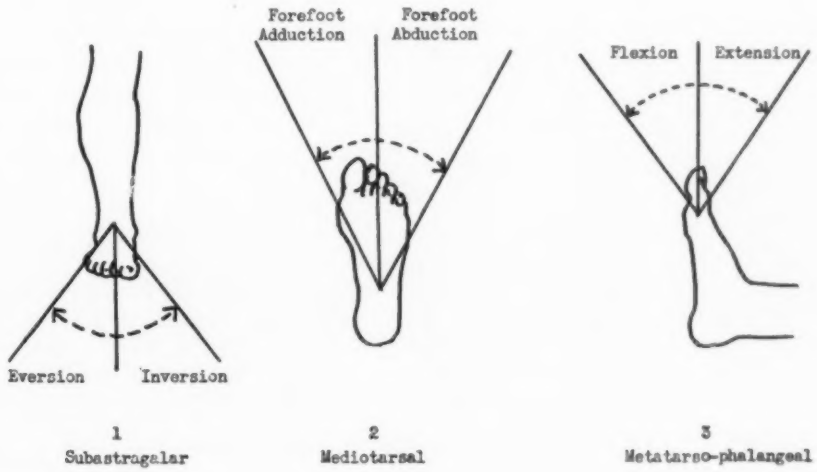
FOOT

Neutral position cannot be defined.

1. Subastragalar motion is inversion and eversion.
2. Mediotarsal joints (forefoot adduction and abduction) tested passively with the os calcis held in neutral.
3. Metatarsophalangeal joints—particularly important in the great toe.
4. Interphalangeal joints—tested in flexion and extension, and for increased lateral mobility.

Motions cannot be accurately measured in degrees.

Mention should be made as to whether motion is abnormally free or restricted, and in which direction there is restriction.



HEMIHYPERTROPHY AND HEMIATROPHY

Congenital Total Unilateral Somatic Asymmetry*

BY CHARLES W. PEABODY, M.D., DETROIT, MICHIGAN

From the Sigma Gamma Clinic and Hospital School for Crippled Children, Detroit

At the outset, it should be specified that the subject matter of this paper concerns itself only with what may be more specifically and suggestively described as congenital total somatic asymmetry. In the fairly exhaustive analysis of the world's literature since 1900, which was involved in this study of the subject, a very considerable number of references with the above titles were found to deal with a variation in the size of one member only, or with localized gigantism of a part or parts of a member. However, partial gigantism may be an accompaniment of total somatic asymmetry, as illustrated in one of the cases reported herewith.

Until recent years, the occasional reports of this condition often referred to it as the rarest of congenital anomalies. In 1927, Arnold Gesell, a neuropsychiatrist published the first significant review and discussion of hemihypertrophy. In this article he made a supplementary report of a case previously described in 1921 and added a second case. Including these two cases, he found that the number of cases of congenital total unilateral hemihypertrophy reported throughout the world up to 1927 was fifty-three. The writer's search has disclosed only three cases of hemiatrophy that were also total unilateral in type. Since then, references have become much more frequent, and, although in the main still consisting only of single case reports, these articles occasionally present more than one case. One observer reported four cases and another, six. Since 1927, a total of thirty-six cases have been reported under the classification of hemihypertrophy and have been found to be total unilateral. In addition, there has been recorded one case that seems to indicate an authentic hemiatrophy of this distribution. Altogether, the literature seems to contain a grand total of ninety-three cases of congenital total unilateral somatic asymmetry, and to these the writer now adds the following six cases of his own observation, with description and comments thereon.

Case 1. A girl, aged thirteen, was first observed by the author five years ago. The clinic record of observations made three years previously noted diffuse bilateral dermal angiomata and total unilateral right hemiatrophy. The height and weight data were not obtained, but photographs suggested average development for age on the smaller side, and on the larger side a girth rather greater in proportion to length. When seen by the writer three years later, her measurements on both sides fell within normal limits for the age; the difference in length was greater in the lower extremities and amounted to one

* Read before the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

FIG. 1

Case 5. Case of notable total somatic asymmetry, showing difference in size of upper extremities at age of ten.

and a quarter inches. A paradoxical lateral curvature, degree one, prevailed in the anomalous lower spinal segments; there was no asymmetry of the remainder of the vertebrae. Normal school grade had been achieved.

CASE 2. A boy, aged ten, was seen recently with asymmetry which had not been positively noted before the age of five, but which had definitely increased since that age. There were no skin lesions, and the child was of normal intelligence. The presence of skull asymmetry was questionable, but the rest of the body was smaller on the left side than on the right. The upper extremities differed in length by one and one-eighth inches and the lower extremities by five-eighths of an inch. The asymmetry included both pelvic and shoulder girdles and the ribs, but there was no perceivable scoliosis in the sitting position. Either of the lower extremities would be within normal measurements for age, although the left upper extremity seemed retarded, and it would not be unreasonable to classify this case as a hemiatrophy.

CASE 3. A colored boy, aged ten, was observed with what seemed to be a congenital lymphangioma of the left leg. However, the left arm, while otherwise normal, was half an inch longer than the right and there seemed to be a little facial asymmetry. The left lower extremity was two and one-quarter inches longer than the right. This increase in length was more apparent in the lower than in the upper half of the limb, and indicated some degree of localized gigantism. When the short leg was blocked up, the boy's height was above normal maximum for age, and, because of the localized gigantism, the case could be classified only as hypertrophy. No further observations were obtained.

CASE 4. A mulatto girl, aged eleven, recently came under the author's observation. There was very apparent total asymmetry of the skull, trunk, and extremities. A slight scoliosis in the sitting position was present, which was eliminated by blocking to level the iliac crests. The measured difference in the upper extremities was one and one-half inches and that in the lower extremities was two and one-half inches, the greater length being on the right side. The patient's weight was about the median figure for her age; her height, with the short leg blocked up, was slightly under the high normal limit, but the subtraction of the amount of blocking gave a figure above the low normal. She appeared to be of average intelligence and had attained a normal school grade. While easily classifiable as hypertrophy, this case illustrates the possibility of dogmatic error. Roentgenographic studies are to be made to ascertain the relative progress toward epiphyseal closure, and appropriate arrest of the long leg has been advised.

FIG. 2

Case 5. Amount of blocking necessary to level the pelvis, and indication of inequality in both segments of limb.

CASE 5. A slender girl of Italian parentage was first observed at the age of eight and her case was diagnosed as a right hemiatrophy. She seemed to be of normal intelligence. The asymmetry was quite obviously total, and the right side of the face was contracted as in a severe torticollis. Except for the asymmetry, the general roentgenographic examination showed no abnormalities. A postural scoliosis was completely corrected by levelling the pelvis. The difference in length of the upper extremities was two and one-half inches and that of the lower extremities was two inches. Three years later these differences had increased appreciably,—three and one-half inches in the case of the upper extremities and three inches in the case of the lower extremities. The musculature was generally proportionate to the skeletal structures. The patient's height, with the short side blocked up, was fifty-three and one-fourth inches and her weight was sixty-four pounds. When the amount of blocking is subtracted from her height, a figure just above the low normal for her age is obtained, while the higher figure falls a little below the median. Her weight of sixty-four pounds is also well above the low normal, but below the median. From these figures alone, the inclination would be to classify her with the cases of hemiatrophy rather than with those of hypertrophy; on the other hand, it is the author's belief that tables of height for age in children of the shorter Italian people might well give reason for the opposite classification. In any event, multiple epiphyseal arrests, rather than lengthening, have been advised, since the difference in the extremities is incompatible with normal body function.

FIG. 3

Case 6. Case of mild general asymmetry plus extreme local gigantism of the long bones of the left lower extremity. In addition to hypertrophy without pathological alteration other than valgus deviation of the long bones, there presented an extreme chondro-osseous hyperplasia of the patella, shown here at an early stage.

This case has seemed to the writer to be of especial interest, not only from the angle of indicated therapy, but also because the asymmetry is many times greater than that seen in any case of hemiatrophy reported in the literature, and it also exceeds quite definitely in degree any reported case of total unilateral hemihypertrophy not associated with local gigantism.

CASE 6. A female whose clinic records were available for almost her entire life. At the age of eighteen months, subacute rickets, with bilateral knee valgus, considerably greater in degree on the left side, was noted. No comment was made as to asymmetry, but a very poor photograph suggested asymmetry in the lower extremities at least. A year or so later, in another clinic, a bilateral osteotomy for knee valgus was done, but no other data were included in the record. The next observation, made when the patient was five years of age, included recognition of the asymmetry. The lower extremities only were measured; the left was longer by two inches than the right and there was some knee valgus and enlargement with distortion of the skeletal outlines at this knee. At the age of six, the knee valgus was degree two and the lengthening two and one-half inches. At the age of seven, the knee valgus was degree three

FIG. 4

Case 6. Condition three years after that shown in Fig. 3, with indication of still abnormally large patella following removal of three-fourths of its original structure. Overgrowth of the greater trochanter is suggested in the hip contours. (See Fig. 6.)

and the difference in length had increased to three and one-half inches. At the age of eight, the knee valgus was degree four and the lengthening four and one-half inches. Facial asymmetry had become very definite and there was a difference in length between the upper extremities of one inch. Pelvic asymmetry was apparent both in clinical and roentgenographic examinations: the left greater trochanter above its epiphyseal line was seen to be half again as large as that on the opposite side; the patella seemed to be the site of a chondro-osseous hypertrophy; and a valgus bend appeared in the upper tibial shaft. This deformity was attributed to static strain from the severe knee valgus in spite of apparatus.

Six months later, the lengthening of the left leg had reached five inches. At this time, a wedge resection in the lower femoral region, including the lower femoral epiphysis, was undertaken (Phemister's work had not then been published), but at operation the capsular reflexions were found to be so high that disorganization of the joint was feared from such a low resection. A very large wedge was removed in the metaphyseal region. This procedure offset the valgus deviation both in the femur and in the tibia and shortened the leg by one and one-half inches, as checked by postoperative measurements. Convalescence was uncomplicated and the patient returned to active life in normal time.

FIG. 5

Case 6. Three years later than Fig. 3, after partial excision of the patella and massive wedge osteotomy of the lower end of the femur. Recurrent valgus (now in the tibia) is seen; also is shown more definitely the asymmetry in the upper extremities, including the shoulder girdle. Blocking (four inches) just levels the pelvis with the knee fully extended instead of slightly flexed as at the moment when the photograph was taken.

Six months later, a further increase in length of one-fourth of an inch was noted. There was also a slight increase of valgus in the tibia. The patellar mass had become so large that malignant degeneration from irritation was feared and this mass was excised. Although the excision included a considerable portion of the normal bone substance, the patella was thicker and larger than normal. The removed specimen was about three

times the size of a normal knee cap. The pathological diagnosis was benign osteochondroma.

By the time the patient had reached the age of ten, the lengthening of the leg had again increased to four and one-half inches, and a valgus deviation of 30 degrees, mostly below the knee, prevailed. No further enlargement had occurred in the patella, but the greater trochanter was now double the size of that on the opposite side, although otherwise normal in roentgenographic appearance. About this time there was performed a very extensive step-cut resection in the upper half of the tibia and the fibula. After this operation, the difference in length was reduced from four and one-half inches to two inches, and the valgus deformity was entirely eliminated by swiveling the fragments at the time of the resection according to the writer's method.

This status prevailed for about six months, but one year later there was again a difference in length of three inches (about the same rate of increase) and an apparent knee valgus, degree two. Roentgenographic examination indicated very little skeletal valgus deviation, but a mass about the size of a patella was revealed at the inner side of the knee in the usual position of the shadow seen in Pellegrini-Stieda disease. At that time, the tip of the greater trochanter had reached the side of the pelvis, and abduction was completely blocked. Shortly afterward, the patient left the city and the author has been unable to obtain further information about her.

This case, the most bizarre of the lot, is of interest in connection with the operative treatment carried out and also because the patient had attained a relative lengthening of seven inches in the lower extremity at the age of eleven, when observations were terminated. Such an increase is unique in a case of unquestionable total unilateral hemihypertrophy, even when combined with local gigantism. Furthermore, certain sites of

FIG. 6

Case 6. Roentgenogram showing pelvic asymmetry and localized gigantism of the greater trochanter.

gigantism noted in this case have not been previously reported in the literature.

DISCUSSION

In this series of six cases, there are some findings which, considered against the background of previous reports, suggest rather unusual if not unique characteristics. The author cannot say that the study has seemed to throw any real light on the question of etiology, and in this report no preventive treatment has been suggested.

In discussing the theories of causation or etiology that had been advanced, Gesell stated that all were of a purely speculative nature and could be given very little logical support. His own theory, also speculative in a way, has nevertheless very good arguments in support of it and seems plausible. He argues biologically that the organism is essentially one of a "two-ness" character, which occasionally manifests itself in various anomalies up to complete twins, and that hemihypertrophy is an instance of partial twinning, or a union into one organism of two different halves. He terms it an epigenetic deviation, rather than a germinal deformity.

Against this theory, is the existence of rare cases of crossed hemihypertrophy, more frequent instances of partial hypertrophy or partial gigantism (one member or one portion of a member), and rare cases of total unilateral hemihypertrophy with associated extreme partial gigantism, of which this present report includes an instance. However, the literature does also include two autopsy reports in which the visceral organs were described as being asymmetrical, in proportion to the somatic portion of the body. Also against the twinning theory is the almost uniform absence of anything but a postural scoliosis and no observations of asymmetrical development of the bodies of the vertebrae, although the ribs seem to be uniformly affected. A theoretically intriguing explanation of asymmetry might lie in a supposition of unbalanced action of the sympathetic chain which might give rise to an inequality in blood flow or distribution with the resulting overgrowth that is commonly seen in the local gigantism or the spurious hemihypertrophy which accompanies diffuse angiomata. No reported observation has been found of differences in surface temperature on the two sides, nor have such differences been apparent to the examiner in the writer's cases.

Gesell does not discuss congenital total unilateral hemiatrophy and, in this connection, it may be fair to say that there is considerable doubt in the author's mind as to whether these two types are really separable as opposite developmental entities. At this stage, it should be emphasized that the condition under discussion consists of a difference between the two sides of the body of a purely quantitative character, as a rule involving uniformly all the included tissues, and it may be more proper—certainly for the vast majority of reported cases—to regard the condition simply as a quantitative asymmetry, rather than specifically as an

atrophy or hypertrophy. In children and adults, all of the cases reported as atrophy, and the great majority of those described as hypertrophy, represent dimensional differences which are well within the maximum range for age of normal individuals. The term used, therefore, may well be the result of the reaction of the observer. For instance, in many cases the difference in size has been considered by the parents from one point of view, and by the reporter from the opposite. In an individual on the low side of normal size, it is easy to denote an asymmetry as an atrophy, and, conversely, as a hypertrophy.

By far the larger number of reported cases of hemihypertrophy have been in infants and it is curious to note that at this age the differences in girth are relatively greater than those in length. The author's own cases consist of older children, with either a perfectly proportional asymmetry in these two particulars, or else a somewhat greater difference in length than in girth. In infants, the reported differences in length have varied between a quarter of an inch and an inch; in children and adults, from half an inch to two inches. This discrepancy in length had apparently occurred before adolescence. About half of the author's series show a difference in length in excess of that in cases previously reported, which continues to increase into adolescence. It has usually seemed to be the case that the asymmetry between the two sides increases in degree in the following order: skull, trunk, lower extremity, and upper extremity. In some instances, the amount of variation has been not only relatively, but actually greater in the upper extremity than in the lower.

Gesell's two patients were mentally deficient to a marked degree. On this fact he placed considerable significance, for, although in the cases reported up to 1927 only 15 per cent. of the patients were found to be mentally deficient, a minority had reached an age of accurate measurability in this respect. However, in all reported cases over five years of age, the percentage of mental defectives is no greater. In the author's series, there were no cases of mental deficiency.

In cases reported as hypertrophy, females were affected slightly more frequently than males and the right side more often than the left. Congenital skin lesions were present in 40 per cent. of the cases of hemihypertrophy; such lesions occurred much more frequently, however, in the few cases listed as hemiatrophy. There was a greater frequency of other congenital anomalies in these cases than is usual.

No consideration has heretofore been given to control or relief of this deformity, probably because the asymmetry has very rarely developed to any handicapping degree. A difference of two inches in the length of the lower extremities has been reported a few times, but usually a moderate shoe lift has easily compensated for the resulting postural complication. In four of the six cases in the author's series, the situation was more serious. Inasmuch as the maximum difference seems likely to prevail in early adolescence, the writer now believes that procedures to bring about epiphyseal arrest may have rather definite indications in cases of major asymmetry.

SUMMARY

The congenital anomaly of total unilateral hemihypertrophy and hemiatrophy is either becoming more frequent or more commonly recognized. Its causation remains without satisfactory explanation. The discrepancy in growth may interfere with efficient body function sufficiently at times to indicate measures of control, which the writer believes should consist of epiphyseal arrests at appropriate ages.

BIBLIOGRAPHY

Barr, D. P.: Congenital Hemihypertrophy and Partial Gigantism. J. Missouri Med. Assn., XXVI, 298, 1929.

Bihler, K.: Ein Fall von angeborener totaler Hemihypertrophie. Zentralbl. f. Gynäk., LVII, 253, 1933.

Bosio, P.: Contributo clinico allo studio delle ipertrofie. (Sopra un caso di emiipertrofia.) Clin. ed Igiene Infant., VI, 219, 1931.

Coccheri, P.: Emiipertrofia totale congenita e reazioni adrenaliniche sottoepidermiche. Lattante, II, 239, 1931.

Dardani, R.: Per un caso di emi-ipertrofia congenita. Pediatria, XXXVII, 535, 1929.

Ducroquet, R.: Hémihypertrophie gauche. Bull. Soc. de Pediat. de Paris, XXVI, 19, 1928.

Esau: Die angeborene Hemihypertrophia totalis des Körpers. Med. Klin., XXVII, 1861, 1931.

Ferri, U.: Un caso di emi-ipertrofia congenita in un lattante. Clin. ed Igiene Infant., II, 18, 1927.

Fordyce, A. D.: Hemi-Hypertrophie Alterne. Arch. Dis. Child., III, 300, 1928.

Gesell, Arnold: Hemihypertrophy and Mental Defect. Arch. Neurol. and Psychiat., VI, 400, 1921.

Hemihypertrophy and Twinning. A Further Study of the Nature of Hemihypertrophy with Report of a New Case. Am. J. Med. Sciences, CLXXIII, 542, 1927.

Glanzer, J.: Total Unilateral Hypertrophy. Am. J. Dis. Child., XLV, 1056, 1933.

Graetz, I.: Über einen Fall von sogenannter "totaler halbseitiger Körperhypertrophie". Ztschr. f. Kinderh., XLV, 381, 1928.

Ghio, A.: Su un caso di emipertrofia congenita totale. Lattante, III, 32, 1932.

Guillain, G., et Bize, P. R.: Hémihypertrophie du corps, de type congénital, total et pur, associée à un dolichocôlon. Rev. Neurol., I, 76, 1934.

Halperin, G.: Normal Asymmetry and Unilateral Hypertrophy. Arch. Int. Med., XLVIII, 676, 1931.

Harwood, Joan: Right Hemihypertrophy and Pubertas Praecox. Proc. Roy. Soc. Med., XXV, Part II, p. 951, (Sect. Study Disease Child., p. 65), 1932.

Kitaigorodskaja, O. D.: Angeborene Hypertrophie im Kindesalter. Jahrb. f. Kinderh., CXXV, 38, 1929.

Kraus, W. M., and Perkins, O. C.: A Syndrome of the Cerebral Origins of the Visceral Nervous System. The Question of Somatic and Visceral Atrophy and a Review of the Reported Cases of Unilateral Atrophy. Arch. Neurol. and Psychiat., XVIII, 249, 1927.

Lange, W.: Zwei Fälle von Hemihypertrophie. Med. Welt, II, 1231, 1928.

McFarland, B. L.: Hemihypertrophy. British Med. J., I, 345, 1928.

Ougrélidzé, M.: Hémihypertrophie congénitale droite stridor laryngé congénital. Nourrisson, XVI, 40, 1928.

Rebez, P.: Un caso di emipertrofia congenita. Gior. Veneto di Scienze Med., VIII, 43, 1934.

SMIDT VAN GELDER, J. H.: Case of Hemihypertrophy. Maandschr. v. Kindergeneesk., III, 39, 1933.

THOMSON, J. E. M.: A Case of Hemangiectatic Hemihypertrophy with Subjective Symptoms of Sacro-Iliac Disturbance Due to Abnormal Bony Development. J. Bone and Joint Surg., XIV, 702, 1932.

TOBIAS, N.: Congenital Hemiatrophy Associated with Linear Nevus; Report of Case. Arch. Pediat., XLV, 673, 1928.

WAKEFIELD, E. G., AND HINES, E. A., JR.: Congenital Hemihypertrophy: A Report of Eight Cases. Am. J. Med. Sciences, CLXXXV, 493, 1933.

WISEBERG, M.: Unusual Case of Hemigigantism. Canadian Med. Assn. J., XXV, 591, 1931.

NOTE.—Some forty-three additional references have been examined and, although titled as hemihypertrophy or hemiatrophy, thrown out as not fulfilling the requirements of total unilateral asymmetry. Thirty-one reports appearing prior to Gesell's first article have also been investigated by the writer. This search of the literature for suggestive titles was carried out at the writer's expense by the Literary Research Department of the American College of Surgeons and the results should remain available for any subsequent study.

EPIDERMOID CYST IN BONE OF SKULL

BY J. HAROLD COUCH, M.B., F.R.C.S., TORONTO, CANADA

From the Department of Surgery, University of Toronto

That an epidermoid cyst should appear within bone is remarkable. That as many as seven of these cysts should be described in the surgical literature is even more remarkable. The peculiar growth of a cyst (purely ectodermal in origin) within bone (a purely mesoblastic structure) merits some comment. Yet such are the facts and the illustrative cases come from widely separated parts of the world. The subject of this communication is the description of such a cyst occurring in the parietal bone of the skull.

Such cysts in bone have been reported, as far as can be determined, only seven times. The first case was reported in Germany, in 1923, by Sonntag who described a cyst occurring in the terminal phalanx of a finger which was treated by amputation. He concluded that the causal relationship between injury and cyst formation must be accepted. Friedländer, also in Germany, described in detail two cases, both of which occurred in the terminal phalanx of the finger. He reviewed the theories of causation of epidermoid cysts in general, and, like Sonntag, with characteristic German thoroughness, treated his cases by amputation.

Christopher, in the United States, in 1925, described a typical case, concluded that it was traumatic in origin and removed readily by operation, and drew attention to pressure atrophy of the surrounding bone.

Harris, of Toronto, in 1930, outlined a characteristic history and suggested the traumatic theory of causation.

In 1932, Curtis and Owen added a case to the literature.

Finally, in a previous article[2], the author described a typical case, suggested that traumatic implantation is the most readily acceptable theory of causation, and outlined a typical history and examination on which diagnosis could be made.

These cases are all in the terminal phalanx of the fingers, which is significant when considering cause.

The only case described as occurring in the skull, so far as the author can determine, is that reported in 1921 by de Castro, who described the removal of a cyst from the scalp, leaving in the skull a round "trephine-like hole", the size of a "four-anna piece". His description suggests that the cyst was infected at the time of operation.

Hartley, however, in 1896, described a similar cyst, implanted by the trauma of a compound fracture of the skull and finally developing not only inside the skull but actually under the dura. There seems to be no reason why these cysts should not develop anywhere in the body if tissue is transplanted.

CASE REPORT

Mr. H., twenty-five years of age, was admitted to the Toronto General Hospital for an entirely different condition. On routine physical examination, a "wen", one centimeter in diameter, was found lying over the right parietal bone. This "wen" differed from other wens, in that a sharp bony margin could be felt all around it. The roentgenogram (Fig. 1) showed a round clean-cut hole through both tables of the skull. The hole through the outer table was larger than that through the inner table. A history of injury to the forehead and scalp, which had occurred years previously and had required stitches, was confirmed by a scar on the forehead. A diagnosis of epidermoid cyst was made.

Under local anaesthesia, the cyst was neatly removed by Dr. Stuart Thompson. It lay under the gala aponeurotica, and under periosteum. After these structures around the bony rim of its cuplike bed were divided, the cyst could be peeled readily from the surrounding tissue, leaving in the skull a clean round hole, resembling a burr hole except that it was lined by a smooth layer of bone so that cancellous bone of the diploe was not seen. The hole through the inner table exposed normal dura. After the cyst had been rolled out, the soft-tissue layers were closed over the bone defect (Fig. 2), and the wound healed by primary union.

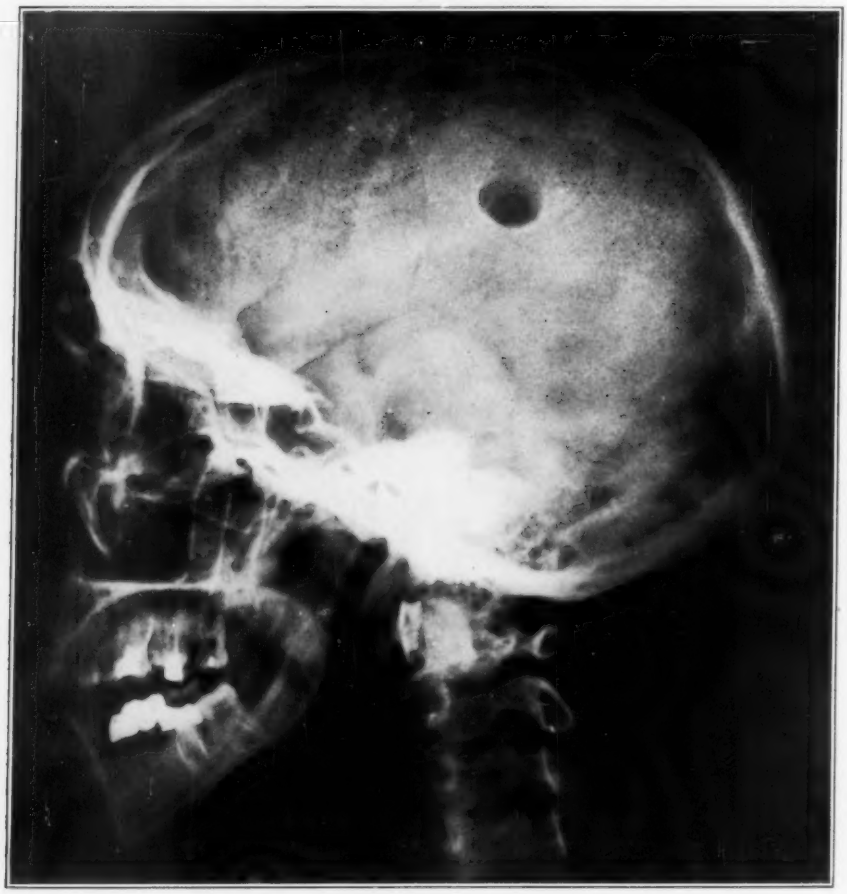


FIG. 1

Roentgenogram showing hole through both tables of the skull.

The presence of the thin shell of bone, hiding diploe, suggests, as did the author's previous case in which the cyst was located in the finger, that bone production is stimulated as well as bone destruction, so that, in response to some unknown stimulus, a shell of new bone is laid down outside as fast as the bone is eroded inside. Thus, the bone production exactly kept pace with the pressure erosion which produced the "burr hole" or nest for the cyst.

This peculiar action of epidermoid cysts in stimulating the production of new bone as well as in producing atrophy, probably due to pressure, has been remarked before. In all cases of epidermoid cysts occurring in the bones of fingers the same phenomenon is observed. Christopher refers in his title particularly to the pressure atrophy of bone, while Harris observes that the phalanx gives the appearance of having been "expanded" by the cyst. However, since bone does not expand, it must be that "new bone is laid down outside as it is eroded inside"[2].

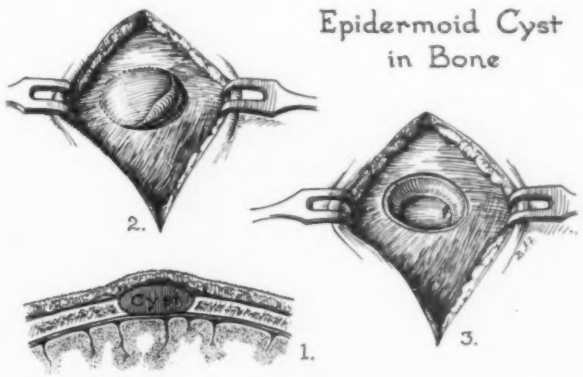


FIG. 2

Semidiagrammatic sketches showing cyst lying in shell of bone under periosteum, but outside dura.

To elaborate various theories of causation of epidermoid cysts is simply to set up straw men for the sake of knocking them down. The following observations, especially when taken together, support the simple and satisfying explanations of traumatic implantation of cells to varying depths in or below the skin where they live and grow and produce an epidermoid cyst.

1. In the first place, epidermoid cysts occur most commonly in the soft tissues of the palmar aspect of the hands of working men. In this respect, the author's observations confirm those of both Unna and Ewing, who point out that these areas are exposed to many small injuries and that cysts in such a location are common in working men. Furthermore, all cases deep enough to be in bone occur in the terminal phalanx.

2. Three cases in the skull are mentioned, two of which are definitely associated with injury. Certainly the head is more prone to cuts or blows than the covered parts of the body.

3. Epidermoid cysts can be produced experimentally[9] by the implantation of epidermoid tissue beneath the surface.

4. Plastic surgeons resort to the device of burying strips or sheets of skin to gain epithelium-lined surfaces. These pieces promptly grow from all edges, complete the circle, and produce a cyst lined by stratified squamous epithelium.

Furthermore, there is some reason to suggest that epidermoid cysts and wens are identical. It has been stated that epidermoid cysts are the result of implantation and that wens are the result of blockage of the ducts of the oil glands. The latter statement is open to question.

The parallel between hand and head is too good to let pass. In the hand, the part of the body most exposed to injury, traumatic implantation produces epidermoid cysts in soft tissue and occasionally even in bone. In the head, also prone to occasional trauma, whether due to a blow, a comb, or a scratch, cysts often occur in the soft tissue and occasionally even in bone. The bone cysts are admittedly due to traumatic implantation. It is suggested, therefore, that the soft-tissue cysts or wens are also traumatic in origin. But, it will be objected, the texts state that wens are attached to the skin and that epidermoid cysts are not. The texts are wrong. There is no reason why an epidermoid cyst of traumatic origin should not be implanted at any depth—in skin, beneath skin, even in bone—and, if close to skin, it will be attached.

At this point, the microscopist will tell us that an epidermoid cyst is lined with stratified squamous epithelium, while a wen, being a retention cyst in an oil gland, is lined with tall secreting epithelium. He then goes naïvely on to add that after some time the taller secreting epithelium is damaged by pressure and replaced by *stratified squamous epithelium*, so that the two are indistinguishable. Further comment is unnecessary.

In conclusion, then, the author not only favors the traumatic-implantation theory of causation, but also suggests that many so called wens or sebaceous cysts are in reality traumatic epidermoid cysts.

REFERENCES

1. Christopher, Frederick: Epidermoid Cyst with Pressure Atrophy of the Adjacent Bone: Report of a Case. Minnesota Med., VIII, 607, 1925.
2. Couch, J. H.: Epidermoid Cyst in Bone. Canadian Med. Assn. J., XXX, 516, 1934.
3. Curtis, F. E., and Owen, C. I.: Sebaceous Cyst of the Distal Phalanx. J. Bone and Joint Surg., XV, 998, Oct. 1933.
4. De Castro, A. B.: A Cyst of Interest. Indian Med. Gaz., LVI, 16, 1921.
5. Ewing, James: Neoplastic Diseases. Ed. 3, p. 1020. Philadelphia, W. B. Saunders Co., 1928.
6. Friedländer, Conrad: Traumatische Epithelcyste im Fingerenglied. Zentralbl. f. Chir., LVII, 209, 1930.
7. Harris, R. I.: Sebaceous Cyst of Terminal Phalanx of Thumb. An Unusual Form of Bone Tumor. J. Bone and Joint Surg., XII, 647, July 1930.
8. Hartley, Frank: An Intracranial Implantation Dermoid Tumor. Ann. Surg., XXIII, 573, 1896.
9. Kaufmann, E.: Ueber Enkatarrhaphie von Epithel. Ein experimenteller Beitrag zur Entstehung der Geschwülste. Arch. f. path. Anat., XCVII, 236, 1884. (Quoted by M. S. Wien and M. R. Caro *in* Traumatic Epithelial Cysts of the Skin. J. Am. Med. Assn., CII, 197, 1934.)
10. Sonntag: Traumatische Epithelzyste im Knochenende an einem Fingerstumpf als Unfallfolge. Münchener med. Wchnschr., LXX, 1055, 1923.
11. Unna, P. G.: The Histopathology of the Diseases of the Skin. Translated from the German by Norman Walker, p. 966. New York, The Macmillan Co., 1896.

CONGENITAL ASTRAGALOCALCANEAL FUSION

BY SIDNEY S. GAYNOR, M.D., NEW YORK, N. Y.

Assistant Adjunct Orthopaedic Surgeon, Hospital for Joint Diseases and Lenox Hill Hospital, New York City

Congenital coalescence of the tarsal bones is a relatively rare anomaly. Recently, however, such instances have been reported with increasing frequency, due probably to the more universal employment of the roentgen ray in the diagnosis of foot disorders. Fusion between the navicular and the astragalus seems to be present in the majority of cases [1, 3, 5, 6, 9, 13]. Coalition of the astragalus and os calcis, however, has been encountered so infrequently that the presentation of another case may be condoned.

P. H., a butcher, thirty-nine years old, was referred to the author for the treatment of traumatically induced low-back pain of four months' duration. The patient had previously enjoyed excellent health, although he had a pronounced valgus of the left heel, of which he had been aware all his life. There was no history of injury or illness affecting his left foot. He did not know of any of his forebears with a similar condition. He had never suffered any pain or disability because of his foot, although it had been the reason for his exemption from military service during the World War.

On examination, the body weight appeared equally distributed between both feet. The heels were maintained in valgus, greatly pronounced on the left. Both forefeet were moderately abducted with the longitudinal arches well preserved. The feet felt normally warm to touch and the arterial pulses were easily palpable in their usual location. There were no callosities on the plantar surface of either foot. The skin of the left foot was normally mobile and no scars were discernible. The web between the second and third toes on each foot was extended distally to the proximal interphalangeal joint.

The musculature of both feet appeared normal in power. Motion at the right ankle and tarsal joints was free and unrestricted. There was absolutely no motion in the left astragalocalcaneal joint, nor could the astragalus be rocked laterally in the ankle mortise. The range of motion at the left ankle exceeded that of the opposite side by about 20 degrees. There was also a wider excursion of abduction and adduction of the left forefoot than of the right.

Roentgenograms were taken of both feet. The right foot appeared normal in all respects. There was complete bony fusion between the left astragalus and the os calcis, with continuous bony trabeculation joining both bones. The posterior external talar tubercle was absent on the left side.

Congenital astragalocalcaneal synostosis was first reported by Zuckerkandl in 1877. Since then, additional isolated reports have been received from Leboucq, Morestin, Pfitzner, and Korvin. In most cases, no consideration of the etiology of this condition has been undertaken. Leboucq observed an astragalocalcaneal fusion in a foetus of sixty-five millimeters, and was of the opinion that this condition was due to failure of proper differentiation of the pre-articular mesenchymal anlage between these bones. Johansson reported a case of multiple congenital malformations associated with fusion of the ankle and proximal tarsal bones. From the mother, he elicited a history of the presence of an unusually small quantity

FIG. 1

Lateral roentgenogram of left foot. Complete bony fusion between the astragalus and the calcaneum, with absence of the posterior external process of the astragalus.

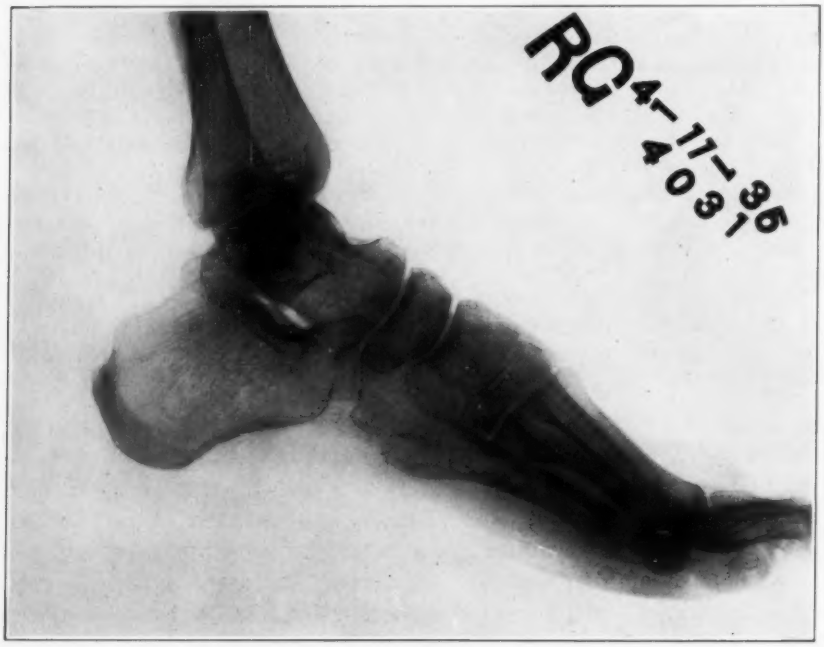


FIG. 2

Lateral roentgenogram of the right foot revealing normal joint space between the astragalus and the calcaneum and a well-defined posterior external talar process.

of amniotic fluid during pregnancy. Therefore, he believed that this case greatly strengthened Murk Jansen's theory of deranged amniotic physiology as the causative factor in the production of congenital deformities.

The possibility that astragalocalcaneal fusion is developmental in origin was suggested to the author by a case presented by Bentzon, who found complete absence of motion at the subastragalar joint associated with unusual prominence of the posterior-superior process of the os calcis and absence of the posterior external talar tubercle. This, he believed, was due to coalescence between the os trigonum and the calcaneum,—a variation of the usual occurrence of the os trigonum as a separate ossicle or of its fusion with the posterior external talar tubercle.* The rarity of this anomaly of the os trigonum is brought out by the fact that Burman and Lapidus did not encounter a similar situation in 493 cases personally observed or in a review of the literature.

It has occurred to the author that, since fusion of the os trigonum to the astragalus is a common finding, and since fusion between the os trigonum and the calcaneum has been observed[2], it is not entirely unreasonable to expect the rare condition in which fusion occurs between the os trigonum and both the talus and calcaneum. Therefore, consideration should be given to the possibility that the aberrant development of the os trigonum is the cause of astragalocalcaneal fusion.

REFERENCES

1. Anderson, R. J.: The Presence of an Astragalo-Scaphoid Bone in Man. J. Anat. and Physiol., XIV, 452, 1879.
2. Bentzon, P. G. K.: Bilateral Congenital Deformity of the Astragalocalcanean Joint. Bony Coalescence between Os Trigonum and the Calcaneus? Acta Orthop. Scandinavica, I, 359, 1930.
3. Bullitt, J. B.: Variations of the Bones of the Foot. Fusion of the Talus and Navicular, Bilateral and Congenital. Am. J. Roentgenol., XX, 548, 1928.
4. Burman, M. S., and Lapidus, P. W.: The Functional Disturbances Caused by the Inconstant Bones and Sesamoids of the Foot. Arch. Surg., XXII, 936, 1931.
5. Holland, C. T.: Two Cases of Rare Deformity of the Feet and Hands. Arch. Radiol. and Electroth., XXII, 234, 1918.
6. Illievitz, A. B.: Congenital Malformations of the Feet. Report of a Case of Congenital Fusion of the Scaphoid with the Astragalus and Complete Absence of One Toe. Am. J. Surg., IV, 550, 1928.
7. Johansson, S.: A Case of Congenital Ankylosis of the Ankle Joints and Other Malformations. Acta Orthop. Scandinavica, V, 231, 1934.
8. Korvin, H.: Coalitio talocalcanea. Ztschr. f. orthop. Chir., LX, 105, 1933.
9. Lapidus, P. W.: Congenital Fusion of the Bones of the Foot; with a Report of a Case of Congenital Astragaloscaphoid Fusion. J. Bone and Joint Surg., XIV, 888, Oct. 1932.
10. Lebouco, H.: De la soudure congénitale de certain os du tarse. Bull. Acad. Roy. de Méd. de Belge, IV, 103, 1890.

* Burman and Lapidus state: "The normal posterior external tubercle of the astragalus is small. In our study, and in accordance with the concept of many authors (Gray, Dwight, Holland, and others), we have considered any enlargement or elongation of the posterior external tubercle due to fusion of the os trigonum with the small posterior external tubercle."

11. Morestin, H.: De l'ankylose calcanéo-astragalienne. Bull. Soc. Anat. de Paris, LXIX, 985, 1894.
12. Pfitzner, W.: Die Variationen im Aufbau des Fussskelets. Morphol. Arb., VI, 493, 1896.
13. Rothberg, A. S., Feldman, J. W., and Schuster, O. F.: Congenital Fusion of Astragalus and Scaphoid: Bilateral; Inherited. New York State J. Med., XXXV, 29, 1935.
14. Zuckerkandl, E.: Ueber einen Fall von Synostose zwischen Talus und Calcaneus. Allg. Wiener med. Ztg., XXII, 293, 1877.

FRACTURE OF THE ACETABULUM WITH CENTRAL DISLOCATION OF THE HEAD OF THE FEMUR

A Method of Treatment

BY FREDERICK A. JOSTES, M.D., F.A.C.S., ST. LOUIS, MISSOURI

From the Department of Surgery, Washington University Medical School and St. Louis County Hospital

The treatment of this type of fracture has long been debated, and justly so, because of its intangibility. No traction device nor mechanical means has, to the author's knowledge, been offered which enables one to replace the acetabular fragments which have been displaced inward by a force from without in the direction of the line of the head of the femur. The method described in the following case was devised to replace the fragments in a fracture of the acetabulum with central dislocation of the head of the femur.

F. P., aged thirty-three, a physician, was injured on May 3, 1933, when the car in which he was riding was struck by another. The contact came on the right side. As a result, the patient sustained a fracture of the pelvis and was in shock. He also sustained fractures of the fifth, sixth, seventh, and eighth ribs on the right side in the postaxillary line. As shown in Figure 1-A, the head of the femur went through the acetabulum, displacing fragments of the acetabulum ahead of it. These fragments, three in number, were quite angular. The superior margin of the acetabular ring rested against the greater trochanter. The leg was in very mild abduction. There was bleeding from the genito-urinary tract, as well as from the mouth. Traction was applied to the right leg and the ribs were fixed with adhesive strapping. After fourteen days, the patient was moved to the St. Louis County Hospital, some 200 miles from the scene of the accident, where the following treatment was carried out.

Method of Treatment

The right leg was first put in Buck's extension. A Thomas splint was used, but no countertraction was exerted against the ischium. Countertraction was obtained by lowering the head of the bed. Lateral traction on the trochanter can best be obtained by use of skeletal traction applied through the trochanter. Since the patient was a physician, a more conservative method was used at his request. A wide sling was made of adhesive and tongue blades, after the fashion of a coaptation splint, and was placed so as to bring about lateral traction on the upper third of the femur. After several days, the head of the femur was brought out to a fairly normal position; however, the fragments of the acetabulum remained displaced as before. Also the fossa for the head of the femur remained so large and so deep that each time that lateral traction was released the head would again dislocate centrally, almost to the position following the accident.

It was then decided that something must be done to restore these acetabular fragments to what approximated their normal position, in order that they might help to maintain the corrected position of the head of the femur. From all indications, only an operative procedure could bring about a reduction. This was considered hazardous. The patient did not regard such a procedure very favorably, nor was he a very good operative risk. It was then decided that, without an anaesthetic, an attempt should be made to replace these fragments by manual manipulation through the rectum. The

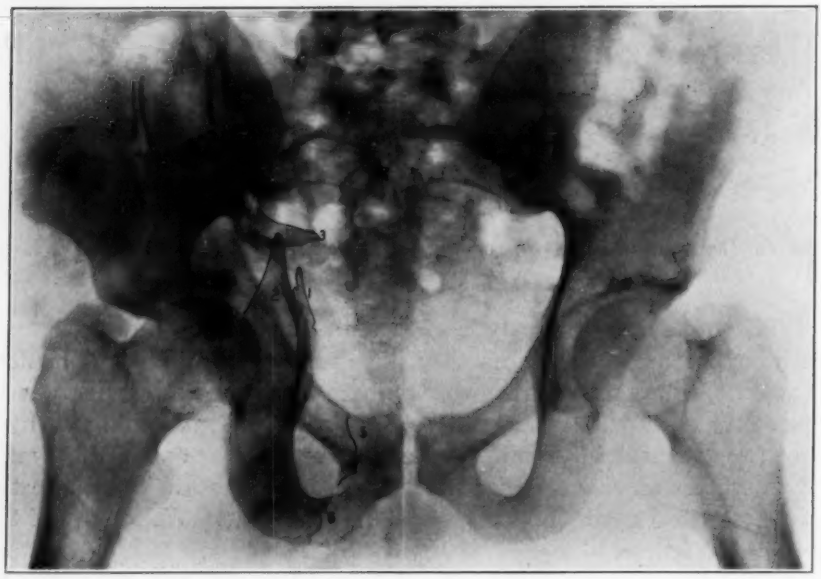


FIG. 1-A

Roentgenogram of pelvis, taken May 18, 1933, showing fracture of the acetabulum with three fragments protruding into the pelvic canal: one (*1*) from the lower anterior (pubic) ramus; one (*2*) from the lower posterior (ischial) ramus; and one (*3*) from the superior (iliac) part of the acetabulum, including that portion of the ilium which approximates the sacro-iliac joint. There is also a fracture through the wing of the ilium (*4*) from about the midpoint of the crest of the ilium between the anterior-superior and posterior-superior spines downward to the superior margin of the acetabulum. Also evident are fractures of both pubic rami (*5*) and (*6*), in close proximity to the synchondrosis.

FIG. 1-B

Roentgenogram, taken May 22, 1933, showing position of the head of the femur after application of traction and manipulation.

facts that these fragments were sharp spicules and that the rectal mucosa might be damaged if too much force over the same area was used were constantly kept in mind.

After having had a soap-suds enema, the patient was prepared for the manipulation. With the patient lying flat on his back and without anaesthesia, the gloved right hand of the operator was used for the manipulation through the rectum. The index finger was first inserted and the sphincter was dilated with the patient's assistance. Two fingers were then inserted to further dilate the sphincter. The inferior fragments, identified as *1* and *2* in Figure 1-A, were palpable at first with some difficulty. After the flat surface of the inferior fragments had been outlined, the patient was warned that firm pressure would be used and that he should relax if possible. Finally, by putting pressure with the index finger on the flat surface of the anterior-inferior fragment and by pulling downward with the left hand on the anterior-superior spine of the right ilium, there was felt a very definite "giving" at the point of pressure over the fragment. Very gently the pressure site was changed to offer a further opportunity for more pressure and at the same time in order not to traumatize the rectal mucosa too severely. Then the pressure was placed over the posterior-inferior fragment; here again, a feeling of "giving" was noted. During this entire procedure, the head of the femur was held in the normal position and relation to the ring of the acetabulum by the traction forces exerted by the Buck's extension and by the lateral traction sling. It will be noted that no effort was made to replace the superior fragments, because of the danger that the finger would ride against the sharp spicule of bone. Additional weight was applied to the Buck's extension, as well as to the lateral traction band, and the leg was adducted very slightly with the hope that pressure from the head would not redislocate the fragments.

FIG. 1-C

Roentgenogram, taken October 10, 1933, showing an approximately normal acetabulum. It will be noted that the superior spicule of bone remains in approximately the original position.

Roentgenograms, taken immediately after the manipulation (Fig. 1-B), proved that the inferior fragments were in better position. The head of the femur remained in good position with relation to the ring of the acetabulum.

After the manipulation, the patient had very little discomfort. The anal ring remained slightly tender for some twenty-four hours. There was no bleeding from the rectum. The patient had an enema after thirty-six hours and suffered no pain on expelling it.

Roentgenograms, taken at the end of five months, showed the relationship between the head of the femur and the acetabulum and between the greater trochanter and the ring of the acetabulum to be normal in comparison with the opposite side (Fig. 1-C).

The patient was kept in traction for a period of seven weeks. Repeated roentgenograms showed that the fragments remained in good position. At the end of seven weeks, a plaster spica was applied with the affected leg in the neutral position and the opposite leg in wide abduction to permit the use of a bed pan. This spica was worn for six weeks. Weight-bearing was permitted three months after reduction.

FIG. 2-A

Fifteen months after accident, showing degree of flexion obtained by the patient.

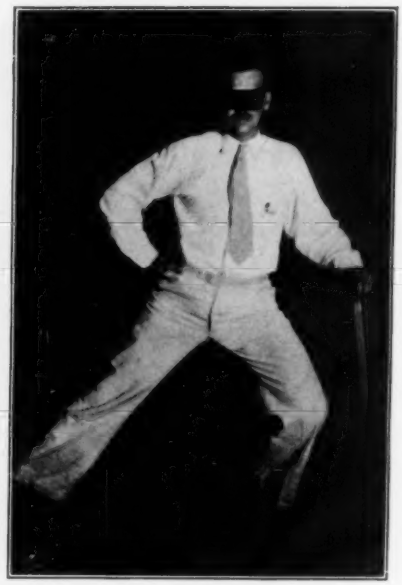


FIG. 2-B

Fifteen months after accident, showing degree of abduction.

End Result

Three years have elapsed since the patient sustained his injury. At present, he is engaged in the active practice of medicine, drives his car, participates in sports, and leads a normal life in every way. He has a normal range of motion in both hips and suffers no pain. (See Figures 2-A and 2-B.)

While this method seems hazardous, the procedure can be carried out with little danger to the patient when reasonable care is exercised. The result obtained in this case seems worth the effort.

AN EVALUATION OF PRESENT-DAY METHODS OF DEALING WITH CONGENITAL DISLOCATION OF THE HIP *

BY A. BRUCE GILL, M.D., PHILADELPHIA, PENNSYLVANIA

The treatment of congenital dislocation of the hip has undergone such a marked change in recent years that there is some confusion in the minds of orthopaedic surgeons. When the methods of Paci and Lorenz became known, bloodless reduction was universally accepted and practised as the rational treatment of this condition. Numerous methods of reduction were devised,—some gentle, many violent. Many tables of statistics were published which led us to believe that from 50 to 70 per cent. of the cases of congenital dislocation could be cured by bloodless reduction. Except in a few isolated instances, nothing was done at that time for those cases which could not be thus cured.

Then the advent and perfection of asepsis wrought a profound change in all fields of surgical procedure. Dissatisfaction with the results of bloodless reduction began to arise. In America, Sherman and Galloway began the practice of open reduction and advocated it as the method of choice in all cases. This bomb, thrown into the camp of the bloodless surgeons, produced some consternation and other emotional disturbances, but caused them to inspect their position more carefully to see if it was tenable. They began to recognize the dangers of forcible manipulation and to insist on the use of only the gentle methods of reduction. But this, certainly, did not increase the number of cases cured by bloodless reposition of the hip.

Furthermore, it has become quite evident that the older meaning of "successful reduction", whether by closed or open methods, is not altogether correct. In many cases, dislocations which had been recorded in our private practice or in our public clinics as having been satisfactorily reduced were found in after years to have recurred. The paper recently published by Heyman calls this forcibly to our attention. For this reason all statistics published more than ten years ago and even more recently must be discarded as giving inaccurate percentages of successful reduction unless they were based upon precise observations of the cases for many years after the reduction.

In recent years, Putti, with his associates and followers, has proved the tremendous advantage of treating congenital dislocation in the early weeks and months after birth. His observation of patients treated by abduction in early infancy shows that at the end of five years or more over 80 per cent. of them have been cured. However, this work, valuable as it is in showing the need for very early diagnosis and treatment, leaves unsolved the treatment of the 20 per cent. or less not so cured and the treat-

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ment of the vast number of patients with congenital dislocation who have reached the walking age before the condition has been discovered. It seems merely to place the young infant in a class by himself, and to emphasize the necessity of the education of the medical profession in order that the obstetricians and pediatricians may make an early diagnosis of this congenital defect.

Another development of the past fifteen years has been the concentrated attack upon the old or irreducible dislocation, in order to ameliorate or relieve the pain and disability attendant upon it. Through the many operations done upon the luxated hip, whether for the purpose of reducing the dislocation or improving a condition not entirely curable, our knowledge of the pathology of congenital dislocation and of the difficulties of complete reduction has been enlarged.

Therefore, we are now more able to discern the important underlying principles of congenital dislocation of the hip and to outline a rational course of treatment by bloodless and open reductions and by palliative operations.

BLOODLESS REDUCTION

Many cases of congenital dislocation of the hip are susceptible of cure by skilful manipulation. Time and experience have proved this beyond the shadow of a doubt. Many cases cannot be so cured. Our first great problem, therefore, is to distinguish between these two major groups. Shall we operate upon all; shall we operate upon none? If the premises enumerated be accepted, the former course must appear as reprehensible as the latter.

Congenital dislocation of the hip is due to the failure of normal development of the hip joint during embryonal and foetal life, as described by Stewart, Putti, Dega, Böhm, and others. The departure from the normal may be very slight or it may be extreme, with many degrees of variation between these limits. We are thus forewarned that no one method of treatment, whether it be a method of bloodless reduction or one of open operation, is applicable to all cases. Furthermore, in hips that are not far removed from the normal, we may reasonably expect to secure a return to normal structure and function by adequate treatment given at the proper time.

In early life, the structures of the hip are most plastic and are molded very easily. As time passes, there is an increasing fixity of the tissues and progressing deformity because of the effort of the elements of the hip joint to adjust themselves to their abnormal relations and functions,—to make the best of a bad situation, as it were. We may, therefore, understand the successful results obtained by Putti and others in the treatment of infants; and, furthermore, we may appreciate that the remainder of this paper deals only with the treatment of individuals who have reached or passed the age at which they begin to walk.

No time limit can be set for successful bloodless reduction. It

FIG. 1-A

Case 1. R. D. R. Bilateral dislocation.

FIG. 1-B

Case 1. R. D. R. Ten years after bloodless reduction: normal motion; normal function; almost normal anatomical development.

depends on the severity of the deformity at birth and its progress afterward. Experience has shown that bloodless reduction cannot often be accomplished after the fourth year.

The surgeon's first decision must be whether to attempt bloodless

reduction or to resort at once to open operation. Contra-indications to the former are rigidity of the hip—sometimes accompanied by rigidity of other joints and by congenital club-foot—high bilateral dislocation, marked deficiency of the acetabulum and deformity of the head and neck of the femur, and an age beyond four years. Bloodless reduction should be attempted in all favorable cases and even in border-line cases.

The manipulation should be gentle and skilful. All the weight of present opinion is opposed to forcible methods of reduction. If the manipulation is unsuccessful, nothing has been lost and no damage has been done. No bones have been broken; no muscles and ligaments have been ruptured; and no cartilages have been damaged by active violence or succeeding excessive pressure.

If the dislocation has been reduced, has the manipulation been successful? By the term "successful reduction" the author means that we may expect the hip to become anatomically and functionally perfect, or so nearly so that it will be the cause of no pain and disability in later life. Time is the only absolute criterion, but in many cases we cannot wait for the passing years to answer our question. The following observations may assist us in determining whether to await the natural outcome or to

FIG. 2

Case 2. W. M. Eight years after bloodless reduction of left hip at age of sixteen months. Four years after reduction, Legg-Perthes disease was noted; healing has now taken place. Normal motion and function are present. Moderate shallowness and obliquity of the acetabulum may be noted, as well as slight deformity of the head which corresponds with the contour of the acetabulum. Would it not be desirable to correct the obliquity of the socket now in order to secure normal development of the head?

FIG. 3-A

Case 3. J. M., a sister of patient in Case 2. Eight months after bloodless reduction at age of two years and six months.

FIG. 3-B

Case 3. J. M. Three years after reduction. Function and motion are normal. The acetabulum has been improved, but is still defective. The head shows evidence of Legg-Perthes disease. Should not the shallowness and obliquity of the acetabulum be corrected by operation at the present time?

FIG. 4

Case 4. R. C. Seven years after bloodless reduction at age of three years. Motion and function are normal. The acetabulum is shallow and oblique. There is moderate deformity of the head corresponding with the acetabulum. Should not the defect of the acetabulum be corrected by operation?

proceed at once to open operation. If, during the manipulation, the head slips very easily into the socket without the "snap" that has been so frequently spoken of and again slips out just as easily, this is a fair indication that the socket is inadequate to retain the head or that the head has not entirely entered it. If the roentgenographic examination following reduction shows the head to be opposite the acetabulum but not within it, as determined by comparison with the normal hip, and the acetabular roof to be markedly defective in size and in obliquity, often containing a gutter, the chances are poor that a successful reduction has been accomplished, and an open operation should be done.

FIG. 5-A

Case 5. A. O'B. One year after bloodless reduction at age of two years. There is marked evidence of Legg-Perthes disease.

If the head is in an apparently adequate acetabulum, the author maintains the reduction with plaster for four months. At the end of this period, the cast is removed and the child is allowed to kick about in his crib for several weeks. If redislocation does not occur,

the child is allowed to walk. If, at any time after the initial four months in plaster, dislocation occurs, an open operation is done. This may seem to be a very arbitrary procedure and test, but the author's experience leads him to believe that it is a sound one for most cases. There may be a few exceptions. This method has the following advantages: first, we determine in four months, and not years later, whether or not the head will remain in the socket—in other words, whether or not the structures of the hip are too abnormal to permit anatomical and functional cure; second, we prevent the atrophy of bone and muscle which is due to prolonged fixation in plaster; and, third, we reduce the medical cost of the case. If some of the readers are fearful of allowing so early weight-bearing on a hip replaced without violence and, therefore, under no great intra-articular pressure, and choose to give the child exercises in water or in any other non-weight-bearing fashion, the author will not quarrel with them. However, the facts should be remembered that the child has been bearing weight on the head of the femur, even though it has not been in the socket, and that nature develops best those structures of the body which are performing their normal functions. Bearing weight is part of the function of the hip. If the head of the femur is so soft that it would be damaged by bearing weight at this period, the hip probably belongs in the category of those which cannot be successfully cured by bloodless reduction.

FIG. 5-B

Case 5. A. O'B. Two years after reduction.

FIG. 5-C

Case 5. A. O'B. Two and one-half years after reduction. Motion and function are normal. The head is slightly flattened and the neck is broad and short. There is moderate obliquity of the socket of the acetabulum.

Doubtless, the

FIG. 6-A

Case 6. H. F. Dislocation of the left hip and subluxation of the right hip.

FIG. 6-B

Case 6. H. F. Seven months after bloodless reduction at age of two and one-half years.

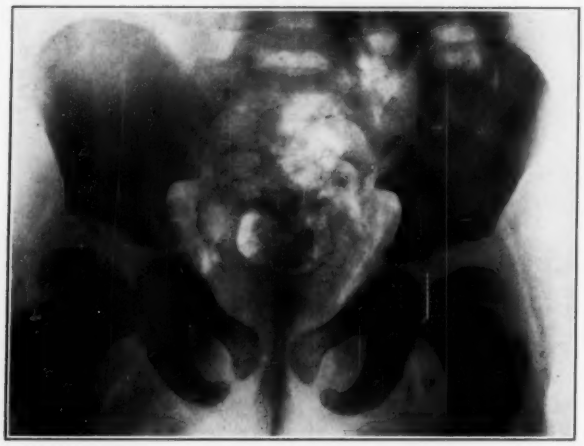

FIG. 6-C

thought has entered the reader's mind that there must be but few hips that can qualify for successful bloodless reduction under these conditions and tests. The author can assure him that there are some, although what the percentage is he does not know. It is smaller than we thought in former years. Why, therefore, not follow the advice of some and operate upon all hips, and thus avoid delay and indecision? Doubtless such a course would be easier for the surgeon. He would no longer need to cultivate his patience and his powers of observation and judgment. He would merely lay out a single undeviating course and pursue it. The mariner at sea adjusts his course to the winds and the tides and the deviations of the

FIG. 6-C

Case 6. H. F. Two years and three months after reduction. Motion and function are normal. The structure of both hips is defective; this is more evident in the right hip which was never fully luxated. Should not both defective acetabula be corrected?

FIG. 7-A

Case 7. D. C. Seven months after bloodless reduction at age of three years and three months.

FIG. 7-B

Case 7. D. C. One year and six months after reduction, showing increasing structural improvement in the acetabulum. Two and one-half years after reduction there was perfect function. Motion was normal and there was no limp.

FIG. 8-A

Case 8. J. B., aged four years.

FIG. 8-B

Case 8. J. B. Four years after bloodless reduction. Both acetabula are defective and there are corresponding defects of the heads of the femora. Reconstruction of the right acetabulum was advised.

compass lest he land on the rocks. As in navigation, so in surgery, there is no fixed undeviating course. Let the operative surgeon show us better results than those obtained by our successful closed reductions before we decide to operate upon all congenitally dislocated hips.

OPEN OPERATION

Operative procedures fall naturally into two classes: first, those which offer a reasonable hope and expectation of effecting a cure, so that the hip joint may be restored to something that closely approaches the normal, both in structure and function; and, second, those which are palliative.

If a dislocated head of the femur can be replaced within the acetabulum, if the acetabulum is or can be made of sufficient depth to admit the entire head, and if the acetabular obliquity is or can be made normal, then we may reasonably expect to effect a cure by open operation. On the contrary, any open operation to cure congenital dislocation which does not take cognizance of these three vital conditions may reasonably be expected to fail. A surgeon who merely opens the hip joint, replaces the head in the acetabulum, and then closes the capsule will have as many failures of permanent cure as the surgeon who replaces the head in the socket by bloodless manipulation. Nor will his good results be any better than the good results of the bloodless surgeon. In other words, the cures effected by both occur in those hips which have departed but little from their normal structural develop-

FIG. 9-A

Case 9. J. F., aged seventeen months.

FIG. 9-A

ment. According to Kidner, the replaced head will remain in the socket after fixation in plaster for three months, or after four months in plaster, as more conservatively stated by the author in considering bloodless reduction. If we review the cases of bloodless reduction which we have failed to cure, although we may have thought the reduction satisfactory at the time, we shall find that the head was not entirely within an adequately deep socket or, if it was, that the roof of the socket was too sloping to maintain the reduction. When Kidner reviewed the results of open reposition he found the same factors in the cases that were not cured.

By what methods of operation, therefore, can we correct

FIG. 9-B

Case 9. J. F. One year and four months after bloodless reduction.

FIG. 9-C

Case 9. J. F. Five years after reduction. This roentgenogram shows very marked structural defects. In this case normal structure and function could not be expected from any method of treatment.

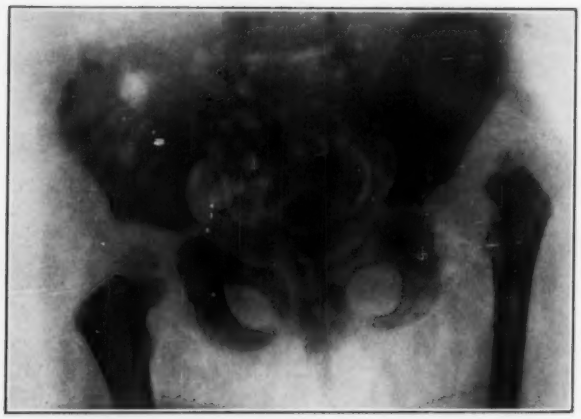

FIG. 10-A

Case 10. M. M., aged nineteen months.

FIG. 10-B

Case 10. M. M. Five months after bloodless reduction. The head is opposite the acetabulum, but not in it.

FIG. 10-C

these defects in the structural development of the hip? Three important considerations must be borne in mind.

1. It must be possible to place the head in the socket without undue tension upon the soft structures of the hip and consequent excessive pressure upon the articular cartilages or without injury to these structures during the replacement of the head. This is just as important in open as in closed reductions. Failure to observe this condition may result in stiffness, in ankylosis even, or in degenerative processes that alter normal structural development.

If the surgeon has already attempted a bloodless reduction, he will be aware of this possible hindrance to open reduction. He may be able to overcome the shortening of the soft structures by gradual traction on the extremity with a turn-buckle

FIG. 10-C

Case 10. M. M. Ten months after reduction.

cast, or with any other appliance which he may have found to be effective. Stretching of the soft tissues should be done slowly in order not to disturb the blood supply to the structures of the hip and in order to avoid sloughing and pain. The traction should be maintained for some time after the head has been drawn down to the level of the socket, so that there may be thorough readjustment to the altered position of the head and, therefore, less tendency to intra-articular pressure after the operation. In accordance with accepted orthopaedic principle, the deformity should be not merely corrected but overcorrected. In mobile hips, this procedure may require a period of a few weeks or a period of four months or more in the more rigid hips.

FIG. 10-D

Case 10. M. M. One year and three months after reduction. During this entire period, the hip was fixed in a plaster cast. This case illustrates the principle that if the head does not remain in the acetabulum after four months' fixation it may not do so even after prolonged fixation in plaster.

FIG. 10-E

Case 10. M. M. Eight months after reconstruction of the acetabulum.

When the hip joint is exposed at the time of operation it may be found that the head cannot be placed in the socket. Kidner, in 1931, called specific attention to the adherence of the capsule to the ilium above the socket and stated that he believed this condition to be the major factor in preventing reduction. In 1923, the author called attention casually to this condition, stating that "the capsule is then detached from the ilium from below the inferior spine backward", and he has always freed this attachment down to the very border of the acetabulum.

FIG. 11-A

Case 11. C. A., aged five years. Traction by a turnbuckle cast was employed.

FIG. 11-B

Case 11. C. A. One year after open operation to reconstruct the acetabulum.

However, he does not believe that this condition is necessarily the major factor in preventing reduction. In the author's experience, the major factor is a short neck or, even worse, a capsule that is attached to the femur at the margin of the articular cartilage. This condition not only prevents the entrance of the head into the socket, as is apparent at a glance, but it often renders it impossible to bring the head forward to the socket even though the head is on a level with the socket. In these cases the capsule must be completely detached from the femur and at times the neck of the femur must be elongated by transposing the trochanter downward on the shaft.

2. The acetabulum must be of sufficient depth to admit the entire head. If the head does not lie entirely within the socket, it is subluxated. Many roentgenographic examinations show that this condition becomes worse instead of better with the passing of time. The body weight is borne only on the inner portion of the head and the outer portion of the acetabular roof. The mechanical laws of the resolution of forces tend to thrust the head without the socket, and the acetabular roof tends to wear away under the abnormal pressure.

Various means are at our command to deepen the acetabulum. It frequently contains fat and fibrous tissue. This may be removed with a scalpel, curved scissors, or a sharp curved gouge. At times, the ligamen-

tum teres is so elongated and thickened that it blocks the entrance of the head. In such cases it must be excised. The inferior capsular fold enters the socket as the head is approximated to the acetabulum. Many writers state that this fold must be incised or cut away. The author has found that usually he is able to push it down out of the way as the head is reduced. This cannot be done when the neck is too short, as described in a preceding paragraph.

FIG. 11-C

Case 11. C. A. Seven years after operation. There is present one-half an inch of shortening, but motion is almost normal. The patient suffers no pain and leads a normal life.

The acetabulum in itself, apart from the soft tissues, may be too small to admit the head. Some surgeons ream out the acetabulum until it is large enough. This method has its dangers,—chiefly consequent stiffness or bony ankylosis. Colonna tries to prevent limitation of motion by covering the head with a layer of the capsule. Some years ago, the author lined a bony socket with a covering of fascia, but discontinued this method because of unsatisfactory results. A capsular or fascial covering of the head partially fills the socket and prevents complete reduction.

The author prefers to leave the acetabular cartilage intact except very occasionally when he pares it off slightly but does not expose the underlying bone. The socket can always be enlarged sufficiently by throwing down a neat and close-fitting shelf along its superior and posterior margins, and, at the same time, reflecting the entire acetabular roof downward to correct obliquity.

On two occasions, the writer performed an open reduction and placed the head in an acetabulum that seemed to be sufficiently deep to hold the head. These hips redislocated. Since that time, he has returned to his original practice of shelf formation and reflection of the roof in all open reductions.

3. The roof of the acetabulum must be neither so defective nor so oblique as to permit the head of the femur to slip out from beneath it, either suddenly or through a period of years. In reviewing his own cases in which relapse has followed bloodless reduction, the author has frequently seen the untoward result of this acetabular obliquity.

It is the writer's belief that an oblique socket makes an oblique head

inevitable during the period of growth, and that, in this instance at least, the head is molded to fit the deformed socket.

This defect may possibly be corrected by reaming out the socket to make it deep enough and its roof sufficiently horizontal. This statement implies that there is sufficient bone at the acetabular site to permit this purpose to be accomplished. The author believes that in many cases there is not this sufficient thickness or depth of bone. In the second place, articular cartilage is thereby removed which is probably never replaced, and a joint is thus constructed which is, at least in this respect, not a normal joint. If we avoid fibrous or bony ankylosis by some such method as that of Colonna we still have a joint that is like an arthroplastic joint, serviceable, possibly, for a time or for many years, but lacking always in at least one of the elements of a natural joint.

Therefore, it still appears to the author more rational to correct this acetabular obliquity by reflecting the roof downward and maintaining it in this correct position by bone wedges driven in firmly above it. Thus, by a plastic bone operation, the socket is reformed, so that it forever resists the upward thrust of the head. The author clearly described this procedure in an article published in 1928. It may be said in passing that many of the poor results of the bone shelf that have been reported in the literature and which have been observed by the author in numerous clinics seem to be due to neglect of the surgeon to carry out this procedure.

Nové-Josserand, in 1933, published a method of correcting acetabular obliquity by detaching the articular cartilage from the roof, reflecting it downward, and filling in the space with bone wedges or chips. The author's method appears more rational for these reasons: it is an integral part of the shelf operation whereby the acetabulum is made large enough to contain the entire head; the enlargement or deepening of the acetabulum is essential in most, if not all, cases that require open operation; the acetabular roof has an even and unbroken flow outward from its inmost portion to the very margin of the shelf, and thus hugs closely the entire upper portion of the head; and, finally, the natural contiguity of the articular cartilage with its underlying bone is not destroyed even temporarily.

PALLIATIVE OPERATIONS

Palliative operations are performed not with the expectation of constructing or of enabling nature to construct a hip joint normal in all its structures and its functions, but with a reasonable hope of lessening, relieving, or preventing the untoward consequences of irreducible dislocation. The severity of these consequences, naturally, must be vastly different in individuals according to age, body weight, physical activity necessary to their usefulness or pleasure in life, the degree of the deformity itself, and whether the dislocation is bilateral or unilateral. These patients may suffer pain in the hip and in the back, they limp, and they may tire easily and be unable to engage in any pursuits of life that require

them to be on their feet. Their disability may be so great that they are confined to the house a large part of the time. On the other hand, there are some women with bilateral dislocation of the hip who reach middle adult life without pain and disability.

Palliative operations are performed largely on individuals more than five or six years of age, but the author has seen children under this age with such marked deformity of the hip that there could be no hope of constructing a normal joint.

These operations are designed to secure one or all of the following results: relief of pain, reduction of the shortening, lessening of the limp, stability, and preservation of motion. Many operations have been invented to accomplish these objects, but present orthopaedic practice has virtually confined itself to two methods,—an osteotomy of the femur or a plastic construction of an adequate acetabulum by means of the so called "shelf operation".

Osteotomy

The methods of osteotomy which are most commonly employed are those of Lorenz, von Baeyer, and Schanz. The author has had no experience with osteotomy because he has always believed that the construction of an adequate acetabulum is sounder surgery in that it more closely approximates nature's method of weight-bearing and locomotion at the hip joint.

The high osteotomy of Lorenz, whereby the sharp distal end of the femur is thrust inward to make contact with the side of the pelvis, appears to rely for its success largely on the fact that a new point of weight-bearing is formed. If through this new contact some or all of the body weight is transmitted to the leg, then the dislocated head of the femur is relieved in part or in whole of this function which it performs inadequately of itself. However, if the large head of the femur cannot sustain the body weight, how can the smaller spicule of the shaft do so unless it comes in contact with the pelvis beneath some ledge or in some concavity which may receive its thrust? If there were some remnant of the original acetabulum into which the upper end of the distal fragment of the femur could be thrust, then one could understand the mechanics of the operation. The author has frequently observed in old congenital dislocations that there is nothing left of the original socket.

The low osteotomy would appear to depend chiefly upon another principle. The femur is bowed inward many degrees at the level of the lower margin of the pelvis. The upper fragment, therefore, is widely abducted and the pelvis is thereby tilted upward on the opposite side. The weight of the body is transmitted to the extremity along an inclined plane instead of on the end of the upright femur. By this arrangement, in accordance with the resolution of forces, more of the upward thrust of the femur is transmitted to the pelvic bones and less to the soft structures which bind the femur to the pelvis.

If the high bifurcation operation also secures wide abduction of the upper fragment of the femur, then one can comprehend its usefulness. The author commends the sane and rational paper published last year by Gaenslen on the Schanz subtrochanteric osteotomy in which the advantages and the disadvantages of this procedure are enumerated. It must be borne in mind, however, that the soft structures of the hip are still bearing an undue strain in that they alone are preventing the pelvis from slipping downward off the inclined plane. It is conceivable that this might lead in time to a recurrence of the pain and fatigue which have been relieved by the operation.

Reconstruction Operation

The reconstruction or shelf operation dates back to König in 1891. He is said to have operated on two children, one of whom died of diphtheria and one of scarlet fever. Its wider use began in this country in 1923 when Dickson read his original paper on this subject. It may be said here, merely as a matter of record, that the author began in 1919 to operate on old irreducible dislocations, but it was not until 1921 that he had evolved the substantial portion of his technique of the shelf operation. In discussing Dickson's paper in 1923, the writer reported nineteen operations on the hip. The author prefers to call the operation "plastic construction of an acetabulum", as the formation of a "shelf" is but part of the operation.

Many of these operations have been done in recent years in numerous clinics both in America and abroad. They have been attended with sufficient success to establish this surgical procedure as one that is definitely and widely useful. Both in the author's experience and in that of others there have been failures to accomplish all the good results that we hope or believe to be possible. Some of these failures have indeed been dismal. The author's worst failures occurred in his early experience before he understood clearly all the factors that make for success, and when he had nothing but his own experience to guide him. Perhaps there has not been sufficient time to evaluate the complete and final results of this operation. It may be that in years to come a disabling arthritis will develop in some of the patients upon whom this operation has been performed as has been predicted by one critic. We must agree, however, that such an event is less likely to occur in a joint which has been made more like a normal joint than it was before. In any event we have secured for our patient at least a few good years free from pain and full of usefulness.

The principles to be observed in this operation are, at least in part, as follows:

1. The new acetabulum should be placed as near the original one as possible.

Preliminary traction, as described in a preceding paragraph, has been found to be useful in drawing the head downward. Its success varies with the rigidity of the hip.

At the time of operation the head of the femur should not be forced and pried downward into a socket.

During the operation the head should be delivered from the capsule except in cases of subluxation when it rests partly within the original

FIG. 12-A

Case 12. L. B., aged forty-five years. The patient complained of severe pain and had marked disability.

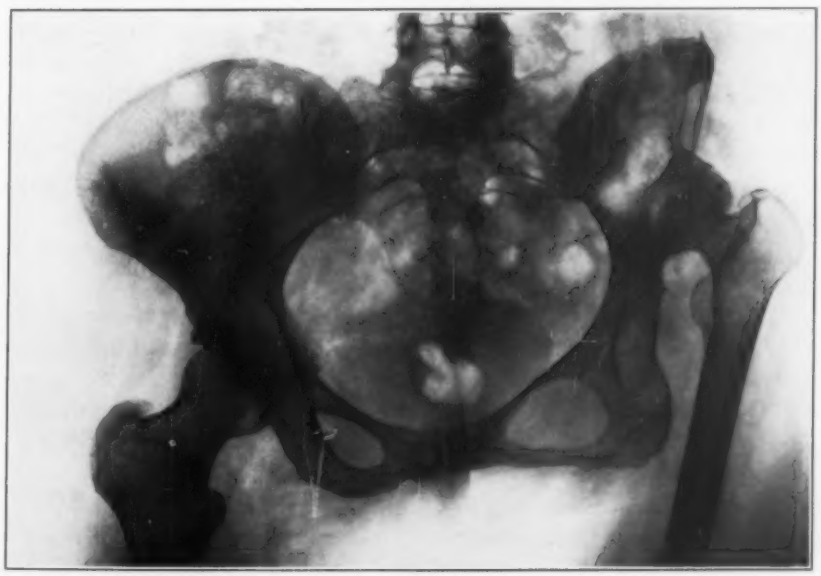

FIG. 12-B

Case 12. L. B. Two years after reconstruction operation had been performed high on the ilium. The patient has no pain, is able to walk long distances, and leads a normal life.

socket. The head is brought forward to the anterior margin of the pelvis, and the femur is moderately abducted. The new acetabulum is constructed at that point where the head then rests against the ilium.

2. The new acetabulum should be made as nearly like a normal one as possible.

A rounded excavation is made in the ilium into which the head fits. Even when the excavation is made high on the ilium where the bone is thin, the femur will not slip upward if it is kept abducted. Once the shelf is constructed, the femur must not be allowed to slip lest the shelf be broken down.

The head is placed in this excavation to determine whether it fits it neatly and will remain in it on abduction of the femur, and is then removed and held out of the way while the bone flap is turned down from the outer table of the ilium.

The flap, semicircular in shape, should be wide enough to cover the cartilaginous head. Its base should not be more than one-fourth to three-eighths of an inch from the round margin of the excavation. It should be detached and bent downward and forward gently and carefully so as not to break it off. If it is done carefully, this flap may be bent downward more than 90 degrees even in an adult.

The head is then replaced in its bed and the shelf bent further until it hugs the head closely above and behind.

If the ilium is sufficiently thick, as it is at or below the inferior spine, the osteotome should then be driven into it almost at a right angle immediately above the bed in which the head lies. The roof of the socket is then pried and reflected downward, as described in the earlier part of this paper.

Wedge-shaped pieces of bone are then driven firmly into the cleft made above the roof of the socket. They project above the shelf and hold it firmly in contact with the head.

If the socket is made high on the ilium, wedges cannot be driven into it because of its thinness. In such a case, the space between the shelf and the ilium is packed with small pieces of bone removed from the excavation and from the side or crest of the ilium.

The margin of the capsule is then brought up over the free edge of the shelf. It will be observed that this holds the shelf down firmly against the head of the femur.

The gluteal muscles are sutured to the crest. They also maintain a pressure on the shelf and the bone fragments above it. The wound is closed and a plaster cast is applied with the femur in sufficient abduction to keep the head of the femur from slipping upward.

One of the author's patients complained of the sharp crest of the ilium following operation. Since then, in young individuals, the author has incised the base of the cartilage that forms the crest, turned the cartilage upward and inward without detaching it from its overlying fascia, removed the bone wedges, and sutured the cartilage in place again

on closing the wound. Thus the smooth round crest of the ilium is preserved.

3. There should be no abnormal pressure on the head of the femur within the socket.

4. After-treatment is directed toward increasing the mobility of the hip joint and strengthening the muscles which move it.

As soon as the stability of the new socket permits, as it does in four to six weeks, the cast is removed and Buck's extension is applied. Baking and massage and active and passive motions are begun and continued. The child is allowed to bear weight gradually after twelve weeks, but physical therapy and exercises are continued for as many months as may be necessary to complete the functional cure.

The poor results from the shelf operation which the author has observed or has seen reported in the literature appear to be due to violation of the principles enumerated in the preceding paragraphs. The causes of these failures may be summarized as follows:

1. If the head of the femur is not moved forward to the anterior margin of the pelvis, the lumbar lordosis is not corrected and the gluteal muscles are not restored to activity. Trendelenburg's sign may be present.

2. If the shelf is formed too high above the acetabulum and is not an integral part of it, the head will slip out of the socket and rest beneath the shelf which may then be broken down or may be absorbed. The shortening of the extremity is increased.

3. If the bone flap which forms the shelf is turned upward from the ilium instead of downward, the operation is manifestly more difficult and the acute-angled space in which the head of the femur is placed in no way resembles the shape of a normal acetabulum. Likewise, tibial grafts driven into the ilium may provide a strong ledge beneath which the head of the femur securely rests, but they cannot be molded to embrace the head as does a normal acetabulum. Why should not the head flatten itself to fit the ledge rather than that the ledge should round itself to fit the head?

4. Stiffness and ankylosis are probably due to excessive pressure within the acetabulum and too prolonged fixation in plaster.

The question of abnormal development of the head of the femur, such as Legg-Perthes disease, as it complicates the treatment of congenital dislocation is very important, but is beyond the confines of this paper. However, it seems pertinent here to call attention to the fact that many cases of Legg-Perthes disease are marked by a shallow and oblique acetabulum. The observations of Murk Jansen and others are well known. If the surgeon should reconstruct this faulty socket by making a bone shelf and by reflecting downward the acetabular roof, might he not prevent the development of Legg-Perthes disease of the head or aid in its cure if it is already present? Furthermore, is the presence of Legg-Perthes disease in a congenital dislocation, whether before or after bloodless reduction, sufficient evidence to conclude that the hip is not amenable to successful closed or open reduction?

SUMMARY

1. Predislocation and dislocation in infants, discovered by examination soon after birth, may be cured in a high percentage of cases by the abduction method of treatment.

2. After the beginning of the walking period of life, bloodless reduction by gentle manipulation should be tried in all favorable and border-line cases.

3. In many cases the dislocation appears clinically to be reduced by the manipulation, but in subsequent months and years it is discovered that subluxation or luxation has occurred or that serious structural abnormalities cause pain and disability of the hip. With the aid of the rules laid down by the author, it is possible in many cases to determine soon after the bloodless manipulation whether or not the hip may be expected to become normal both in structure and in function.

4. If manipulation is unsuccessful, open operation should be performed.

5. At every open reduction an attempt should be made to correct the obliquity and the shallowness of the acetabulum if these conditions are present, as they very frequently are.

6. Palliative operations should be performed in cases of irreducible dislocation to eliminate or reduce as much as possible the symptoms of pain and disability or to prevent their development. In such operations, no attempt is made to restore the normal anatomy of the hip.

7. The osteotomies of Lorenz and Schanz are undoubtedly useful in selected cases.

8. The reconstruction of an acetabulum, or the "shelf" operation, if properly performed, has proved to be a very valuable procedure in almost all cases.

CONCLUSION

The author has attempted to present a rational and practical working basis for the treatment of congenital dislocation of the hip. The time limit set upon this paper forbids anything approaching an exhaustive dissertation upon this vast and voluminous subject. Different surgeons may have their own methods and devices, but they must not depart from fundamental principles if they would attain success.

It appears to the author that the educative work undertaken by Putti to further early diagnosis and treatment is the most important recent development in the treatment of congenital dislocation of the hip.

REFERENCES

Böhm, Max: Das menschliche Bein. Seine normale Entwicklung und die Entstehung der Wuchsfehler (Hüftluxation, X- und O-Beine, Knick- und Plattfüsse, Klumpfuss). Stuttgart, Ferdinand Enke, 1935.

Colonna, P. C.: Congenital Dislocation of the Hip in Older Subjects. Based on a Study of Sixty-Six Open Operations. J. Bone and Joint Surg., XIV, 277, Apr. 1932.

Dega, W.: Richerche anatomiche e meccaniche sull'anca fetale rivolte a chiarire l'etio-

logia e la patogenesi della lussazione congenita. Chir. d. Org. di Movimento, XVIII, 425, 1933.

DICKSON, F. D.: The Operative Treatment of Old Congenital Dislocation of the Hip. J. Bone and Joint Surg., VI, 262, Apr. 1924.

GAENSLEN, F. J.: The Schanz Subtrochanteric Osteotomy for Irreducible Dislocation of the Hip. J. Bone and Joint Surg., XVII, 76, Jan. 1935.

GILL, A. B.: Discussion on Paper of Dr. Dickson. J. Bone and Joint Surg., VI, 271, Apr. 1924.

Operation for Old Congenital Dislocation of the Hip. Surg. Clin. North America, VI, 147, 1926.

Operation for Old or Irreducible Congenital Dislocation of the Hip. J. Bone and Joint Surg., X, 696, Oct. 1928.

Plastic Construction of an Acetabulum in Congenital Dislocation of the Hip—The Shelf Operation. J. Bone and Joint Surg., XVII, 48, Jan. 1935.

HEYMAN, C. H.: Late Results of Treatment of Congenital Dislocation of the Hip. J. Am. Med. Assn., CVI, 11, Jan. 4, 1936.

KIDNER, F. C.: Importance of Capsule Attachments in the Reduction of Congenital Dislocation of the Hip. J. Bone and Joint Surg., XIII, 104, Jan. 1931.

Comparative Analysis of the Results of Open and Closed Reductions in Congenital Dislocation of the Hip. J. Bone and Joint Surg., XVII, 25, Jan. 1935.

NOVÉ-JOSSERAND ET POUZET: Technique opératoire. Nouveau procédé de restauration du toit du cotyle dans la luxation de la hanche. Rev. d'Orthop., XX, 240, 1933.

PUTTI, VITTORIO: Anatomia della lussazione congenita dell'anca. Bologna, Licinio Cappelli, 1935.

STEWART, S. F.: The Physiological Treatment of Congenital Dislocation of the Hip J. Bone and Joint Surg., XVII, 11, Jan. 1935.

AN APPARATUS FOR CORRECTION OF SUBLUXATION OF THE TIBIAL HEAD

BY JAY L. HUTCHISON, M.D., DURHAM, NORTH CAROLINA

From North Carolina Orthopaedic Hospital, Gastonia

This paper presents a brief description of an original piece of apparatus used for correcting a posterior luxation of the tibia on the femur. The apparatus is not complicated and can be made without any expensive outlay of material or time. At the time when this paper was written, this apparatus had been used satisfactorily in only one case resulting from a burn contracture about the knee joint.

CASE REPORT

W. W., a child, came into the hospital with a flexion contracture of the knee resulting from severe untreated burns about the knee, especially on the posterior surface. The flexion deformity was corrected by resecting the scar tissue and by applying tube grafts to the defects, followed by wedging leg casts and skin traction. When the leg was in full extension, it was noticed that there was considerable deformity about the knee, due to a well-developed subluxation of the tibia on the femur. After traction and casts had failed to correct this deformity, a capsulorrhaphy was performed and appropriate postoperative treatment was given. In spite of this procedure, the deformity still remained (Fig. 1).

On February 8, 1935, Steinmann pins were inserted in the lower end of the femur and the upper end of the tibia away from the epiphyseal lines. The pins were placed so that more of the shaft would be on one side than on the other, in order that the balance would be on the side against which the force of the pins would be directed. After appropriate dressings had been fitted to the pins, a short, heavy cast was applied around the thigh to act as a buttress against the force exerted by the upper arm. A transverse bar

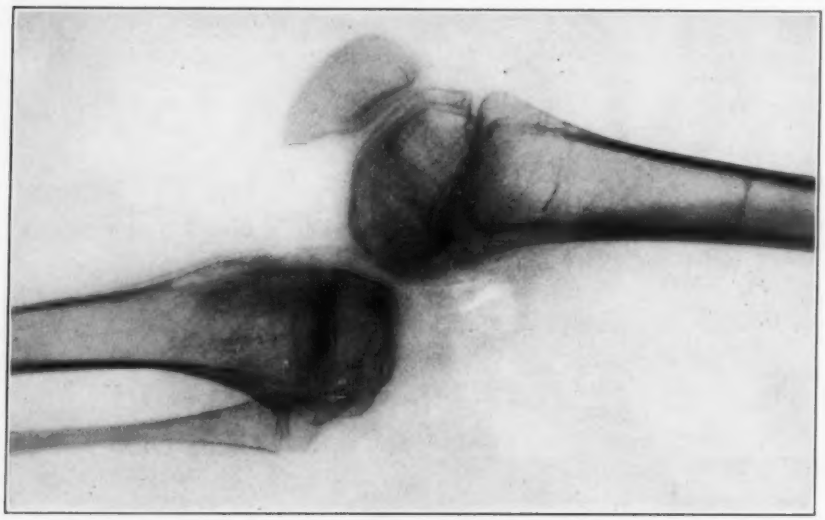

FIG. 1

Roentgenogram showing the knee joint following capsulorrhaphy and before applying the rotation-distraction device.

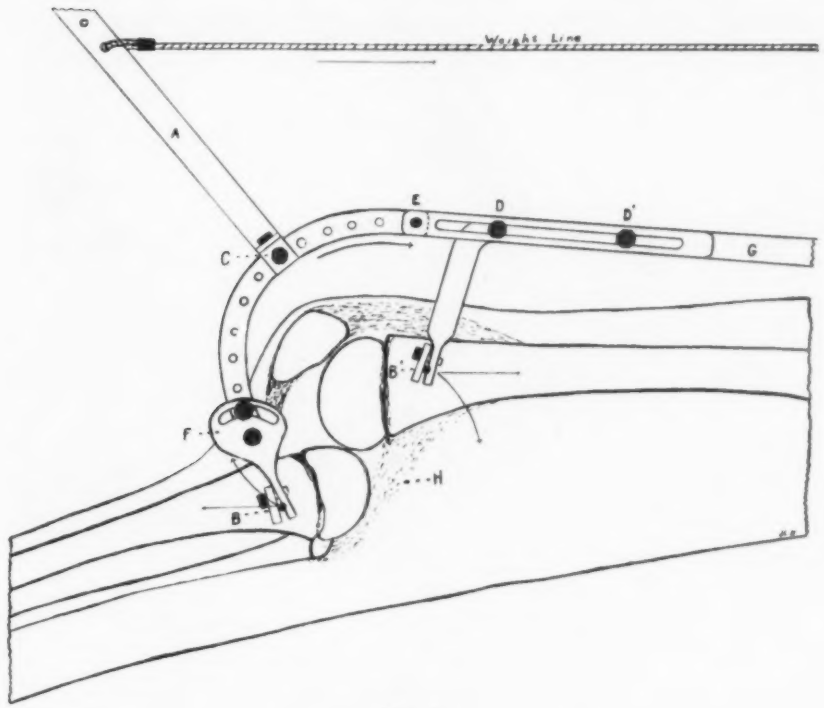

FIG. 2

Diagram illustrating rotation-distraction apparatus as applied to the knee joint. All parts of the apparatus are paired with the exception of the upright traction bar, *A*.

The two sections are tied together by their grasp on the Steinmann pins, *B* and B^1; the U-shaped adjustable base of the traction bar, *C;* and through-and-through adjustable bolts, *D* and D^1. The distance between *B* and B^1 may be varied by adjusting slot DD^1 and (or) arm *F*, with consequent increase in amount of distraction. The lower section of the apparatus rotates around the axis, *E*. Arm *G* is strapped to a short spica or leg cast. Arrows indicate the direction of corrective forces. *H* indicates marked thickening of the capsule in the case reported.

was incorporated in the cast dorsally to give stability to the part. If it is desired, a short spica may be used instead of the leg cast, thus obviating the necessity of strapping the cast to the frame to prevent the leg from riding upward as a result of the action of the weight upon the unfixed hip. The rotation-distraction apparatus (Fig. 2) was attached to the pins and the weight line was strung to an overhead frame.

Starting with two pounds, the weight was gradually increased to eight pounds. At no time was there marked discomfort to the patient. Fifteen days after application of the apparatus, roentgenograms showed the subluxation well corrected and the condyles of the femur and tibia well separated (Fig. 3).

Since it was felt that the capsule was thoroughly stretched, the apparatus and the Steinmann pins were removed. This was followed by the application of a snugly fitting leg cast with the leg in complete extension. A short time later, physiotherapy was instituted to develop the quadriceps muscle which had become stretched and weakened by the prolonged flexion and resultant disuse.

On March 31, 1935, approximately seven weeks after application of the rotation-distraction apparatus, the roentgenogram showed a satisfactory joint relation, and the child was dismissed wearing a walking cast. When the patient was last seen in the Clinic, function was quite good and the external appearance of the knee was much improved.

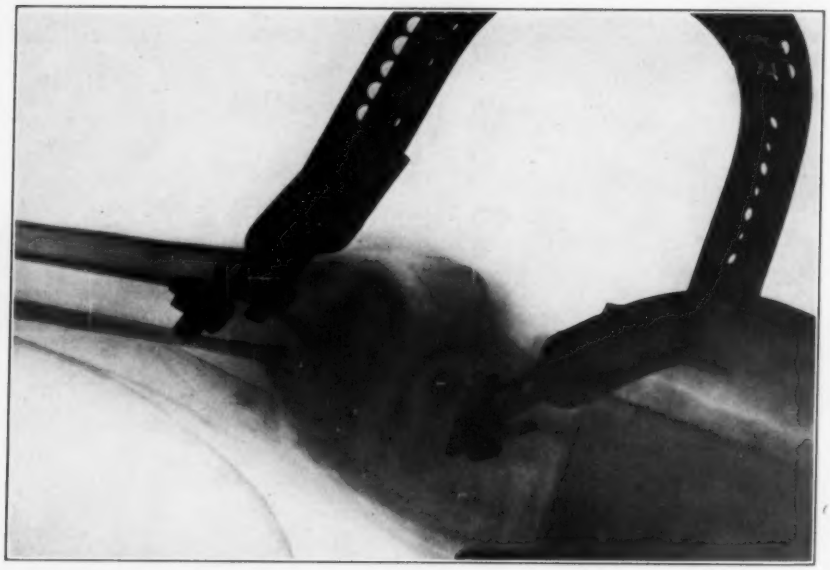

FIG. 3

W. W. Showing apparatus in place just before removal of the pins. Note separation of the joint surfaces.

SUMMARY

In the case of marked subluxation of the tibia described, correction was obtained by the use of an original piece of apparatus, employing rotation-distraction forces acting upon Steinmann pins in the lower end of the femur and the upper end of the tibia. The apparatus is workable and practical for similar conditions. Its use is also suggested in the treatment of anterior displacements of the tibia on the femur by applying it in the reverse position.

The author wishes to express thanks to Dr. William M. Roberts, Chief Surgeon of the North Carolina Orthopaedic Hospital, for use of clinical material from his Service.

LOCALIZED OSTEITIS FIBROSA IN THE NEW-BORN AND CONGENITAL PSEUDARTHROSIS

BY EDWARD L. COMPERE, M.D., CHICAGO, ILLINOIS

From the Division of Orthopaedic Surgery, Department of Surgery, The University of Chicago

The rare occurrence of congenital new growths or cystic changes in the osseous tissues of the new-born was recently pointed out by Witting and Gillespie. These authors found three cases of congenital benign bone cysts reported in the literature and added a fourth case in which there was an area of destruction with fusiform swelling, extending from the middle third of the fibula to a point half an inch above the distal epiphyseal line. The irregular trabeculation noted in their published roentgenograms and the absence of cysts in two similar cases, the reports of which follow, leads the author to express the opinion that the case of Witting and Gillespie, which was not explored and studied microscopically, may have been localized benign osteitis fibrosa without cyst formation.

CASE 1. J. D., a male, aged two weeks, was a well-nourished and well-developed infant, born at the Chicago Lying-In Hospital on January 10, 1934. The maternal history and the prenatal course were normal. A swelling was found on the inner surface of the left lower leg when the patient was taken home from the Lying-In Hospital. This swelling, near the knee, was about the size of a pigeon's egg, and was firm, immovable, and apparently attached to the bone. The patient held the leg rigidly and objected to its being moved. No other abnormal findings were noted. Roentgenograms (Fig. 1), taken on January 23, 1934, showed a cystlike area in the upper half of the left tibia, which involved more than the lateral half of the diameter of the bone for a distance of approximately one-third of its length. The remaining cortical portion of the bone on the medial side had been fractured at the level of the center of the area of bone absorption or destruction. Blood-chemistry determinations, on January 25, 1934, showed the normal inorganic-phosphate content of 6.9 and calcium content of 9.6. Other laboratory studies were normal. The diagnosis was localized osteitis fibrosa of the left tibia with a solitary bone cyst.

An operation was performed on January 26, 1934, and a spindle-shaped swelling was found. A strip, one centimeter wide and four centimeters long, was cut from the periosteum, exposing a cavity filled with what looked like firm fibrous and granulation tissue. There was old blood at the site of a recent fracture through the remaining cortex. The fibrous contents were curetted out, the bony edges were chiseled off, and iodine was applied. The wound was closed without drainage and healed by primary intention.

The material from the bone defect was cultured, but no growth was obtained.

Roentgenograms, taken on February 12, 1934, showed progressive filling in of the lesion of the tibia, but the fracture line was still present. On March 12, 1934, roentgenograms showed evidence of union of the fracture. There was buckling of the shaft, however, with convexity to the medial side. On May 7, 1934, roentgenographic examination showed that the operative defect was filling in. The tibia was quite straight, when viewed in the lateral position, but in the anteroposterior view there was tilting of the proximal articular surface, accompanied by lateral bowing of the fibula (Fig. 2).

The bowing and swelling at the site of the lesion gradually increased. A roentgeno-

gram, taken in December, eleven months after the operation, showed refracture, reabsorption of bone, and enlargement of the cystlike lesion.

The patient was admitted to the hospital and a second operation was performed on December 12, 1934. A white fibrous mass which was partly ossified was found to occupy the site of the lesion noted in the roentgenogram. This mass was excised. No cysts or soft areas were found. A whole-thickness tibial graft was placed across the defect after the tibial bowing had been corrected.

Union followed this operation and there has been progressive improvement. Roentgenograms of June 17, 1935 showed solid bone union and satisfactory alignment (Fig. 3). When the

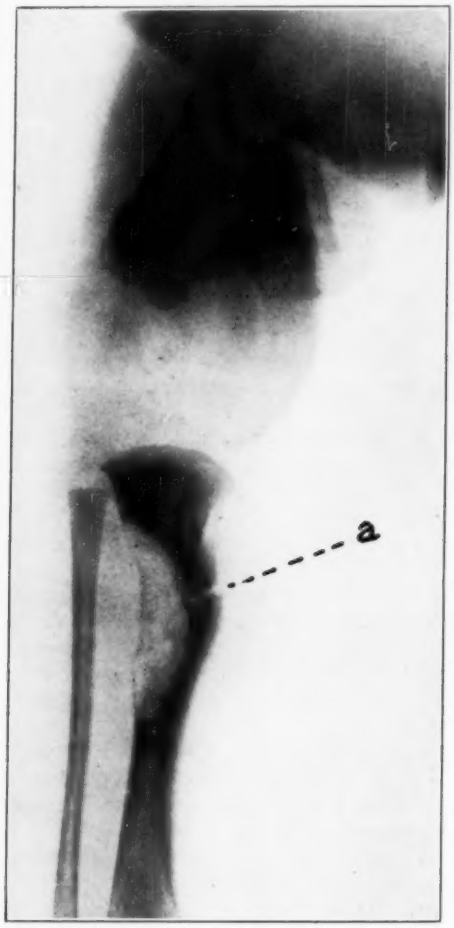

FIG. 1

Case 1. This roentgenogram, taken January 23, 1934, two weeks after the birth of the patient, shows the cystlike area in the proximal and middle thirds of the tibia with dissolution of continuity (*a*) in the remaining portion of cortical bone which bulges medially, suggesting new bone formation in an attempt to compensate for loss of bone laterally.

FIG. 2

Case 1. Roentgenogram, taken May 7, 1934, three and one-half months after the partial excision of the lesion. The cavity is beginning to fill in with new bone and the fracture has united. The tibia is bowed medially and seems to be proportionately longer than the fibula when compared to the roentgenograms of January 23, 1934. This bowing has produced a sloping surface of the upper end of the diaphysis of the tibia. Five months later, a roentgenogram showed extension of the lesion with refracture and non-union.

FIG. 3

Case. 1. Roentgenograms, June 17, 1935, seven months after the second operation. The ununited fracture which was present has healed, and there is no indication of recent bone absorption.

patient was seen in the Out-Patient Clinic on November 1, 1935, the legs were the same length, there was no curvature, and function was normal.

Pathology

The specimen removed at the first operation consisted of two pieces of cortical bone, a strip of periosteum one centimeter long and four-tenths of a centimeter thick, and small pieces of soft, reddish tissue from the central portion of the lesion.

Microscopic sections of a portion which included cortical bone showed bone trabeculae, osteoid tissue, and masses of rounded cartilage cells with dark-staining nuclei (Fig. 4-A). The marrow spaces were filled with dense fibrous tissue and the bone lacunae were lined with osteoblasts. The fibrous tissue within did not blend into the cartilage, but was sharply differentiated. The bone trabeculae extended into the cartilage mass and there were definite areas of cartilaginous new bone formation. In this section, there

FIG. 4-A

Case 1. Photomicrograph of a section of the tumor and fragments of cortical bone overlying the lesion. There is both new bone formation, as evidenced by the osteoid tissue (*a*) which is undergoing ossification and seems to be formed from either fibrous tissue (*b*) or cartilage cells present about it, and bone absorption, as evidenced by the lacunar spaces (*c*) which are lined with fibroblasts (*d*). The marrow is fibrous and vascular.

was both bone absorption and two types of new bone formation,—that from fibrous tissue to osteoid tissue or osteoid tissue formed by the fibroblasts lining the lacunae, and bone from cartilage. This cartilage may have been formed in the callus of the healing fracture. A few cystic spaces were noted in the cartilage mass.

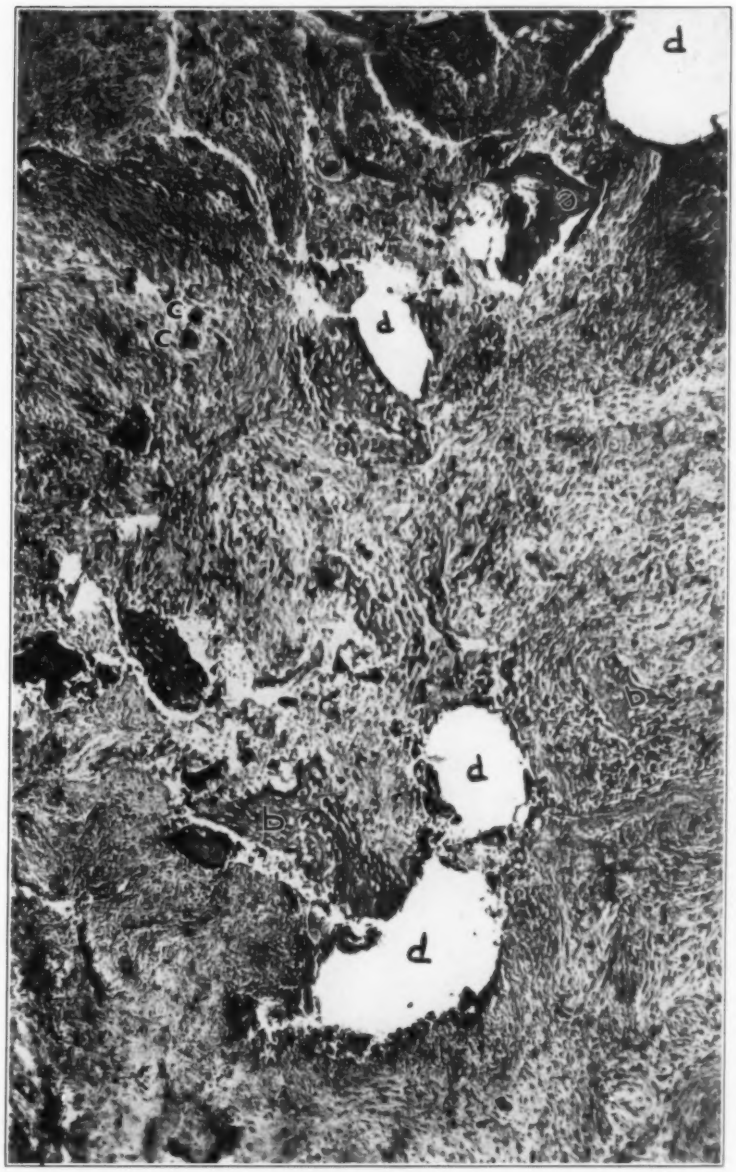

FIG. 4-B

Photomicrograph of a section of the reddish material curetted from the lesion, which consists of dense fibrous tissue arranged in interlacing bands and whorls. Small spicules of bone (*a*) and areas of osteoid tissue (*b*) are noted. A few foreign-body-type giant cells (*c*) are scattered through the fibrous tissue and there are also round and plasma cells. Note the areas of cystic degeneration (*d*).

The section of reddish tissue curetted from the lesion consisted of dense cellular connective tissue arranged in interlacing whorls (Fig. 4-B). A few strands of osteoid tissue and small bone trabeculae were undergoing lacunar absorption. An occasional foreign-body type of giant cell was identified and round cells and plasma cells were

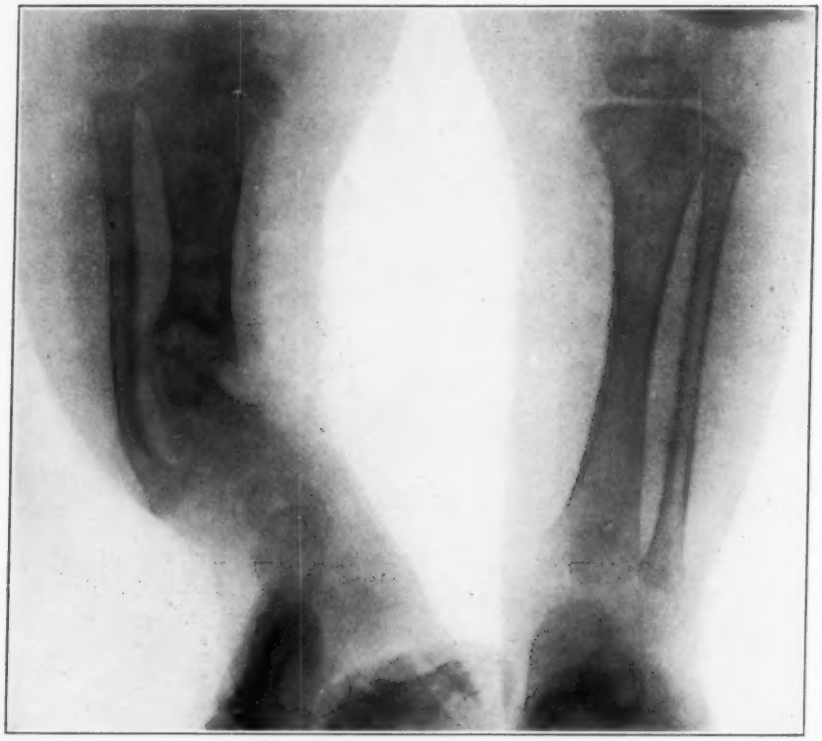

FIG. 5

Case 2. Roentgenogram of bones of both legs at the age of five months. There is a lateral curvature of both bones of the right leg. About five centimeters above the distal end of the right tibia, there is an ununited fracture through a cystlike area. The proximal end of the distal fragment appears to be articulating with the basket-shaped, slightly expanded distal end of the proximal fragment.

scattered through the fibrous tissue. Many small areas of cystic degeneration were noted.

CASE 2. H. M., a female. Two days after the birth of this patient, the mother had observed a "cracking, grating" sensation in the lower third of the child's right leg. When the child was between four and five months of age, the mother had noted that the right leg was bowed laterally and forward and that there was a visible and palpable swelling just above the ankle. A roentgenogram (Fig. 5) showed a defect in the right tibia and complete loss of continuity. The distal end of the proximal fragment was cupped and the distal fragment was articulating with it. The fibula was bowed laterally, but was not fractured. The family physician had operated and, after the removal of some "tumor" tissue, had stated that the lesion was a bone cyst. The leg had then been immobilized for approximately one year. At the age of fifteen months and again at the age of eighteen months, the leg had been "fractured" in order to correct the lateral and anterior bowing.

The patient was first examined in the University of Chicago Clinics on February 3, 1930, at the age of twenty-two months. She was not able to walk and, about two inches proximal to the right ankle, there was marked lateral bowing of the tibia and fibula; motion at this site indicated loss of continuity in both bones. A roentgenogram (Fig. 6) revealed the same cystlike expansion and central absorption of the shaft of the tibia proximal to the site of fracture that was present in the roentgenograms made at the age of

five months. In addition, there was an ununited fracture of the fibula at this level, with thinning or sharpening of the proximal ends of both distal fragments and complete disalignment and separation of the fractured ends. Some callus formation was noted about the fracture of the fibula and a lesser amount about the tibia.

The patient was operated upon on February 5, 1930. The cystlike area was found to be filled with fibrous tissue and callus. The fragment ends of the tibia were freshened and the bones aligned. A full-thickness bone graft, five inches in length, cut from the crest and the anteromesial surface of the tibia, was divided in the middle and one graft was placed on the mesial side and the other on the lateral side of the tibia, extending across the defect. (See Figure 7.)

Non-union resulted, with refracture of the lateral graft and absorption of the lower half of the mesial graft, and a second operation was performed on October 6, 1930. Intermedullary fibrous callus was curetted out and four full-thickness bone grafts from the left tibia were inserted so that they almost completely surrounded the right tibia at the site of fracture.

Microscopic sections of some of the material removed from the site of the non-union showed very cellular fibrous tissue with some callus and new bone formation.

Following the second operation, solid bony union occurred. A roentgenogram (Fig. 8), taken December 15, 1933, showed union and regeneration of the shafts of the tibia and

FIG. 6

Case 2. Roentgenograms, February 3, 1930, when patient was twenty-two months of age. There is a faint callus, but the fracture of the tibia has not united, the deformity has increased, and there is now an ununited fracture of the fibula.

the fibula. There was no narrowing of the epiphyseal line or other indication of growth arrest.

DISCUSSION

Cases of benign solitary bone cyst in the new-born have been reported by Stierlin, von Beust, and Frangenheim, as well as by Witting and Gillespie. On the basis of histological examination, Stierlin, von Beust, and

FIG. 7

Case 2. Roentgenograms, taken one month after an open reduction and insertion of two full-thickness onlay grafts, showing evidence of beginning union. Subsequent roentgenograms showed that one graft was absorbed after failing to unite and the second graft fractured. At a second operation, eight months after the first, four full-thickness grafts were used and union was obtained.

Frangenheim believe that cystic disease of the bone is the underlying condition in pseudarthrosis. Inglis and Camurati report that in their histological studies of the lesions of pseudarthrosis there was little evidence of osteitis fibrosa cystica. Kaufmann states: "Bone cysts, usually pseudo-cysts, occur occasionally from softening of former dense tumors, particularly the typical chondromas, more rarely the centrally cystic enchondro-fibromas."

FIG. 8

Case 2. Roentgenograms, taken December 15, 1933, three years after the second operation, showing complete union of both the tibia and the fibula, good alignment, and regeneration of the cortex and medullary bone.

The tumor in the first case reported in this paper was composed of cartilage and fibrous tissue in about equal amounts, and there were small, almost microscopic cystic spaces in both the fibrous and the cartilaginous areas. Microscopically, this tumor could be classified as an enchondrofibroma with beginning cystic degeneration which might conceivably have led to the formation of a solitary bone cyst, and is evidence supporting the theory of Schlange. It must be remembered, however, that a fracture was present and the cartilage may have originated from the callus and not from the primary tumor.

The lesion reported by Witting and Gillespie was similar in roent-

genographic appearance to the two cases which the author has reported, but it was located in the fibula where congenital pseudarthrosis without involvement of the tibia is rarely, if ever, seen. The site of the lesion in congenital pseudarthrosis is usually in the middle or lower thirds of the tibia, as in Case 2, while the lesion which is described in Case 1 was in the upper third.

The fracture noted in Case 1 was recent, undoubtedly occurring either at the time of or shortly after the delivery of the infant, for at operation old blood was still present at the site. Both grossly and histologically, this fracture was similar to fractures occurring in bone cysts or localized osteitis fibrosa which are seen in young children in bones in which congenital pseudarthrosis does not occur or is quite uncommon. The healing of the fracture and the partial filling in of the defect within two months after the fibrous tissue had been cleaned out from the lesion is similar to that noted in other cases of localized osteitis fibrosa similarly treated in this clinic.

The postoperative reabsorption and refracture in both cases indicate growth and extension of the tumor tissue. Complete healing followed more careful excision of the fibrous tissue and insertion of tibial bone. In the older case it was necessary to operate a second time, using multiple full-thickness bone grafts in order to obtain permanent union.

SUMMARY

Of these two cases of solitary localized bone lesions, which were either congenital or occurred in early postnatal life, one was a case of localized osteitis fibrosa of the proximal third of the tibia and the other was a typical congenital pseudarthrosis in the lower third of the tibia. Both cases resulted in fracture and non-union.

Four similar cases have been reported in the literature. Three of these were described as cystic lesions. In the fourth case, there was no operative interference to demonstrate the presence or absence of cyst formation, and no fracture occurred.

In Case 1, bowing of the tibia was noted, suggesting that this lesion may have stimulated longitudinal growth from the proximal tibial epiphysis so that the tibia became relatively longer than the fibula and bowed, due to lack of support on the lateral side where the defect in the bone was most extensive.

Union was obtained, followed by normal function, through the use of full-thickness tibial bone grafts.

Each of these cases adds support to the contention of Stierlin, von Beust, and Frangenheim that fibrous or cystic disease of the bone is the underlying cause of congenital pseudarthrosis.

REFERENCES

CAMURATI, MARIO: Le pseudoartrosi congenite della tibia. Chir. d. Org. di Movimento, XV, 1, 1930.

FRANGENHEIM, P.: Angeborene Ostitis fibrosa als Ursache einer intrauterinen Unterschenkelfraktur. Arch. f. klin. Chir., CXVII, 22, 1921.

INGLIS, KEITH: The Pathology of Congenital Pseudarthrosis of the Tibia. J. Coll. Surgeons, Australia, I, 194, 1928.

KAUFMANN, EDWARD: Pathology for Students and Practitioners. Authorized Translation from the German by S. P. Reimann. Vol. II, p. 1226. Philadelphia, P. Blakiston's Son & Co., 1929.

SCHLANGE: Quoted by Kaufmann.

STIERLIN, E.: Ostitis fibrosa bei angeborener Fraktur. Deutsche Ztschr. f. Chir., CXXX, 85, 1914.

VON BEUST, A. T.: Ostitis fibrosa und Knochencyste bei angeborener Unterschenkelfraktur. Deutsche Ztschr. f. Chir., CLII, 60, 1920.

WITTING, V., AND GILLESPIE, J. B.: Benign Bone Cyst in the New-born. Report of a Case. Illinois Med. J., LXV, 451, 1934.

PATHOLOGICAL DISLOCATION OF THE SACRO-ILIAC JOINT

BY J. B. L'EPISCOPO, M.D., BROOKLYN, NEW YORK

In a fairly thorough review of the literature, the author has not been able to find reported a case of a true pathological dislocation of the sacro-iliac joint. One case of congenital dislocation and many cases of dislocation of the sacro-iliac joint following trauma of various types and degrees have been reported. Because of the apparent rarity of this lesion, the author feels that it is worth while to record the following case which came under his observation.

Mrs. D., a white female, aged twenty-four, was admitted to the Gynecological Service of the Kings County Hospital on March 9, 1933, complaining of pain in the lower back. The patient stated that the pain in the back had started spontaneously about one week before admission and that she had first noticed it on attempting to turn. The pain had gradually become worse until she was admitted to the Hospital. She also gave a history of having fallen on her abdomen five weeks previously, at which time she was two months pregnant. This fall was followed by a slight bloody discharge, and abortion two weeks later. The patient had no chills or fever at that time, and had no medical attention.

Relevant physical findings on admission were: temperature 101 degrees, respiration 22, pulse 80. The patient was a pale, white female, well-nourished, well-developed, with a poor hemic component. The first heart sound was roughened and had a systolic blow. The abdomen was soft. There was tenderness over the symphysis pubis and a yellow discharge from the vagina. Also, tenderness over the left sacro-iliac joint was elicited on pressure.

The blood count showed:

White blood cells—9,800 per cubic millimeter
Polymorphonuclears—69 per cent.
Red blood cells—2,624,000 per cubic millimeter
Hemoglobin—55 per cent.

A roentgenogram, taken on March 15, 1933, showed an area of destruction at the lower part of the left sacro-iliac joint, and a displacement upward of the symphysis pubis on the left side.

Because of the continued sepsis and apparent absence of pelvic pathology, the patient was transferred to the Orthopaedic Service on March 16, 1933, with the probable diagnosis of suppuration of the left sacro-iliac joint. Traction was applied to the left leg on the same day, with marked relief of pain.

Because of return of pain and a continued temperature, another roentgenogram was taken on March 29, 1933. This showed essentially the same findings as the previous roentgenogram, except that there was an increase in the amount of destruction in the sacro-iliac joint.

On March 30, 1933, the sacro-iliac joint was opened from behind through a window in the ilium and sacrum, which permitted drainage of the pelvic cavity in which there was found a large accumulation of pus.

As the sacro-iliac joint was entered, it was found that the ilium moved very freely from side to side and up and down. It was actually a pathological dislocation upward of the entire os innominatum on the sacrum.

The wound was packed with vaselin gauze and the postoperative treatment was that usually employed for infections of the sacro-iliac joint. The temperature ranged from 99 to 105 degrees until April 11, 1933. From that date on, it gradually declined until it reached normal.

The patient was allowed up in a wheel chair on June 23, 1933. By July 10, 1933, the

FIG. 1

Shows riding upward of the entire left os innominatum at the symphysis and sacro-iliac joint. A postoperative defect, resulting from the drainage of suppurative arthritis of the sacro-iliac joint, is also shown.

wound had healed, and the patient was discharged, walking well and wearing a sacro-iliac belt. The belt was probably not necessary.

The patient was last seen in the spring of 1935 at which time she had had no recurrence and appeared and felt normal. A roentgenogram at this time showed fusion of the sacro-iliac joint with a small sequestrum at the site of operation, which was not causing any symptoms.

COMMENT

The author doubts very much whether the suppurative condition alone was responsible for the dislocation, because the os innominatum cannot slide upward on the sacrum unless there is also a separation at the symphysis pubis, so that we must have a loosening of both of these joints for the condition to occur.

This patient gave a history of having a spontaneous abortion a few weeks before the onset of the acute infection of the sacro-iliac joint. She was about two months pregnant at the time abortion occurred. We do know that, probably because of the action of some hormone, there is a relaxation of all the pelvic joints during pregnancy. However, relaxation of these joints takes place in a lateral direction. Because of the pre-existing physiological relaxation at the symphysis pubis, it is the author's belief that the coincident infection of the sacro-iliac joint, with resulting destruction in that joint, was responsible for the upward displacement of the os innominatum on the sacrum.

A MODIFICATION OF THE BALKAN FRAME

BY H. O. FOUCAR, B.A., M.D., LONDON, ONTARIO, CANADA
Chief of Surgery, St. Joseph's Hospital

For use in the average hospital, it is desirable that a Balkan frame be made as a single unit and of durable construction. It should be easily stored, transported, and set up ready for use with the essential accessories in place. It should, however, be adjustable in order that it may fit beds differing in size and be used on different types of patients. It should not necessitate the services of a special technician, but should be easily handled by interns, nurses, or orderlies.

With these requirements in mind, the frame about to be described was constructed. It is seven feet long, four feet wide, and six feet, four inches high and may be made by any plumber.*

The following is a complete list of the material used to construct the frame shown in Figure 1:

58 feet of ½-inch galvanized water pipe (outside diameter, ⅞ of an inch);
- 4 pieces, each 6 feet, 4 inches in length, threaded at each end (*CCDD*);
- 2 pieces, each 7 feet in length, threaded at each end (*EE*);
- 4 pieces, each 4 feet in length, threaded at each end (*ABFF*);
- 1 piece, 2 feet, 8 inches in length, threaded at one end (*G*);

1 solid bar, ⅜ of an inch thick and 2 feet, 3 inches long, threaded at one end to fit ⅜-inch T piece (*G*);
6 ½-inch caps on ends of *E*, *C*, and *D*;
2 ½-inch elbows between *A* and *E*;
11 ½-inch T pieces; thread of cross limb is reamed out;
1 T piece, ½ an inch by ⅜ of an inch; thread of cross limb is reamed out;
7 1½-inch swivel pulleys;
7 metal rings, 1½ inches by 3/16 of an inch;
4 stove bolts and nuts, ¼ of an inch by 1½ inches;
2 light chains, each 2½ feet long;
8 leather straps, each ¾ of an inch wide and 19 inches long;
8 buckles;
16 saddler's rivets.

The important technical procedure is the reaming out of the cross limbs of all of the T pieces. The threads are removed, so that these T pieces may slide along or rotate around the straight bars to which they are attached. By studying Figure 1, it is not difficult to see how the frame is assembled. The uprights and cross pieces are constructed first; the rings and pulleys are placed in position; the long horizontal bars are then added; and, finally, the ends are capped, so that the frame cannot be taken apart again except with a pipe wrench. To attach the pulleys, the rings are cut diagonally and are sprung to enclose the swivel rings of the

* The materials cost $13.00 at local retail prices and the labor, at ninety cents an hour, amounted to $5.00, making a total cost of $18.00. If these frames are made in quantities by hospitals, the cost would be even less.

pulleys. The leather straps are passed through the buckles for a distance of three inches and are then folded back on themselves. These short ends are fastened by two saddler's rivets to the other part of the strap, enclosing snugly the legs of the frame as illustrated in Figure 1. The foot uprights are perforated at intervals of four inches from the three-foot to the five-foot level to allow elevation of the cross piece. A chain is fastened by means of a bolt and nut to the lowest hole. To the other end of the chain is attached another bolt which may be inserted in any hole to maintain the required elevation.

Figure 1 shows the frame folded flat like a card table for storage or transportation. It weighs sixty pounds and can be carried by one man or, more easily, by two. Any objection to the weight is offset by the fact that the frame is carried as a single unit; there is no loss of time selecting parts or making multiple trips to the store-room.

The folded frame is placed flat on the floor beside the patient's bed; the foot end should be toward the foot of the bed and the legs should be underneath. For erecting the frame, two people are necessary, one at each end. The total time consumed is that required to loosen eight straps, to lift up the top frame, which allows the legs to fall down as in a card table, and to fasten these eight straps to the legs or bars of the bed. During this part of the procedure, the frame must be steadied, but once it has been firmly strapped to the bed it is stable. When the frame is no longer needed, the straps are undone, the legs are folded under and strapped, as shown in the diagram, and the frame is ready for storage. It will be noted that the foot cross piece (*B*) ends in T pieces which may slide along the long horizontal bars (*EE*). This is to allow the frame to fit beds of different lengths. The four uprights (*CC* and *DD*) also terminate in T pieces, so that they not only rotate around the

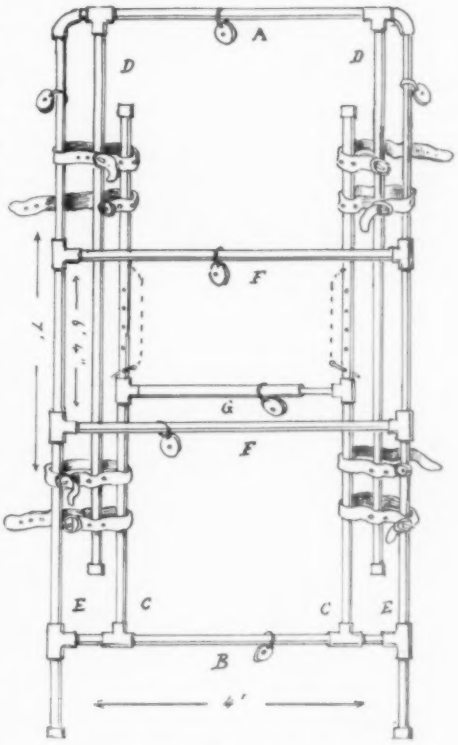

FIG. 1

Showing frame folded for storage or transportation.

A: Head cross piece.
B: Foot cross piece which slides along *EE*.
CCDD: Uprights which rotate around or slide along the cross pieces *A* and *B*.
EE: Long horizontal bars.
FF: Movable transverse bars.
G: Transverse bar on foot standard for extension of the lower limb.

transverse bars (*A* and *B*), but also slide along them; thus the frame can be adjusted to fit the width of the bed. On the foot standard (*CC*) is attached a transverse bar (*G*) which is telescopic to fit beds of different widths and which may be raised or lowered for the purpose of extension of the lower limb at varying angles. The top frame is wider than the ordinary hospital bed. When the legs are firmly strapped to the bed, the whole top may occupy the midposition (Fig. 2, *A*) or it may be pushed well over to one side (Fig. 2, *B*) to allow suspension to the side of the frame of an arm or leg in abduction without the addition of any other piece to the frame itself. The cross pieces (*FF*) may also be moved merely by pushing them to the desired place; the new position is maintained by the downward pull of the weight applied, by simple friction, or by slight jamming of the cross pieces. To one of these may be fastened a handle for use as an overhead crane.

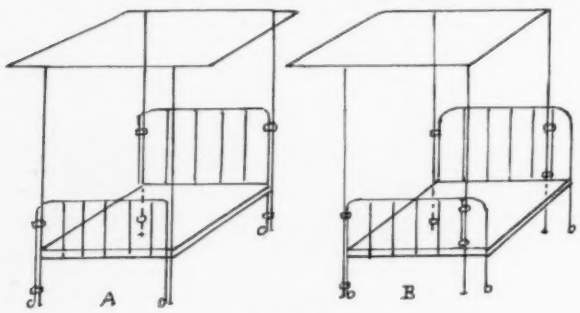

FIG. 2

Showing frame attached to bed.
A: Frame in midposition.
B: Top pushed to one side. Where greater distance is needed, the far uprights may be strapped to the bars of the bed instead of to the legs as shown.

Pulleys on metal rings are placed at suitable points. The ends of the pipe are capped to protect the floor and also to prevent the apparatus from being taken apart. The straps are of heavy leather and are riveted on each side of the uprights, so that they move up or down, but cannot slide over the caps. There is little excuse for the loss of a strap, because the only time it is touched is when the frame is actually being put up or taken down. At all other times the straps should be securely buckled. If a strap breaks it can easily be replaced. If heavy straps are used, this should not occur often because the strain is well distributed. The frame is made high enough to clear the heads of those caring for the patient, a minor detail but important nevertheless.

This simple and durable Balkan frame has been used by the author and has proved to be very efficient.

The author wishes to acknowledge the technical assistance of Mr. J. P. Bell, engineer at St. Joseph's Hospital, in the construction of this frame.

FRACTURE OF ANKYLOSED EXTREMITIES *

BY SIGMUND EPSTEIN, M.D., NEW YORK, N. Y.

The following cases reveal the unusual strength of ankylosed extremities in resisting fracture when subjected to accidental impact.

CASE 1. J. W., male, twenty-six years of age, had been operated upon in infancy for osteomyelitis of the right hip. A stiff hip and a seven-inch shortening of the limb were the sequelae. Due to an automobile accident on October 7, 1921, the patient was brought into the hospital with a severe injury to the right hip. A roentgenogram (Fig. 1) disclosed an ancient replacement of the hip joint by a dense mass of sclerosed, bony bridging. The acetabulum, femoral head, and most of the neck were missing. Beyond the fused area, an oblique fracture had occurred through the intertrochanteric line. There was slight outward displacement of the shaft. Under an anaesthetic, the limb was put up in slight abduction in a long plaster-of-Paris spica. At the end of seven weeks, the limb had been restored to its condition before the injury.

FIG. 1
Case 1. Fracture just below ankylosed hip.

CASE 2. J. S., a male, aged forty-two years, had had a stiff knee in the vertical position for many years. Then he fell down a flight of stairs, and was disabled immediately. He was admitted to the hospital wearing inadequate basswood splints and complaining of acute pain. Roentgenographic examination (Figs. 2-A and 2-B) revealed an irregular line of fracture running obliquely across the head of the tibia; there was no displacement of the fragments. Line tenderness, corresponding precisely to the fracture line, was noted. A plaster-of-Paris cast was applied from the groin to the ankle. The patient was soon able to walk and his stay in the hospital was short. At discharge, function was as good as before the accident.

CASE 3. E. W., a young female, had an elbow joint that had become ankylosed (90 degrees) as a sequela of an infectious arthritis. The patient fell subsequently and fractured the humerus across the condyles,—just above the line of the completely stiffened

*Presented at a meeting of the New York Physicians'-Yorkville Medical Society, New York, May 22, 1935.

joint (Figs. 3-A and 3-B). Immobilization in plaster-of-Paris resulted in a limb as useful as it was before the accident.

These cases are rare, and, at times, may be overlooked. Payr records that fracture through such bony ankylosis never occurs at the point of welding. In ankylosed knees, he observed fractures of the shaft of the femur, as well as of the shaft of the tibia. He describes a characteristic case of bony ankylosis of the knee, following tuberculosis, and shows a diagonal supracondylar fracture of the femur, ending above the region of the adductor tubercle. He also describes a shoulder ankylosis in which fracture occurred "in the neighborhood" of the rigidly ankylosed joint. In the American literature, fractures of the tibial shaft have been reported in ankylosed knees, following the removal of bone grafts.

Experience has taught that roentgenograms in two positions are indispensable. In Case 2, the injury was thought to be a ligamentous or muscular tear, as evidenced by the application of basswood splints before admission. The lateral view (Fig. 2-B) discloses four transverse lines of arrested bone growth in the shaft below the fracture. This condition has been described by Harris. A comminuted popliteal fragment can be seen posteriorly.

During the course of some arthroplasties for ankylosis, forceful

FIG. 2-A FIG. 2-B

Case 2. Anteroposterior and lateral roentgenograms of fracture just below ankylosed knee.

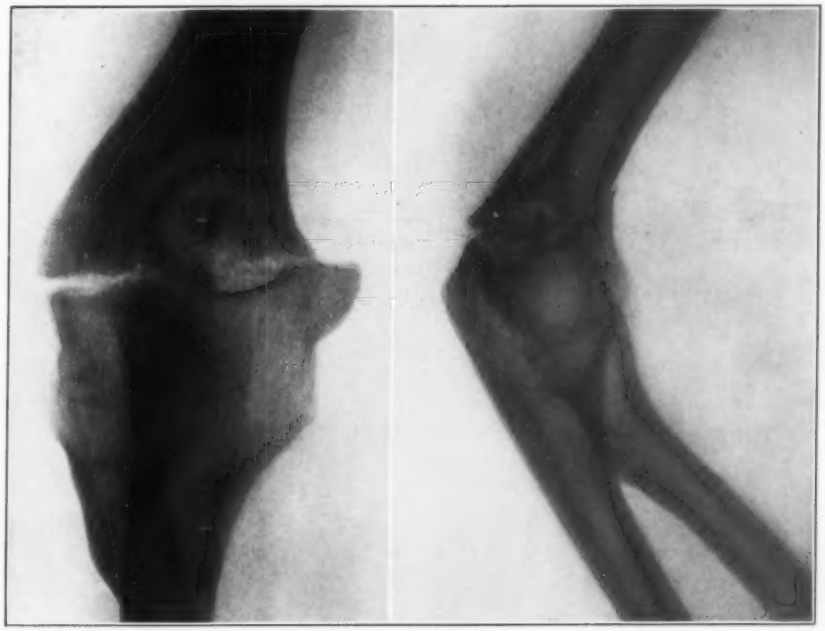

FIG. 3-A

Case 3. Fracture just above ankylosed elbow.

FIG. 3-B

Case 3. Lateral view of supracondylar fracture just above ankylosed elbow.

mallet blows upon the sharpest chisels barely chip these hard and firmly soldered joints, which clearly demonstrates why accidental impact has its breaking effect, not at the joints, but below them. A new surgical *neck*, in healthy bone, is the point of greatest weakness. The densest of these welded joints are found after purulent gonorrhoeal arthritis or coxofemoral osteomyelitis.

CONCLUSIONS

The completely welded, eburnated articulation of two long bones of the extremities, known as true ankylosis, is a mass of bone of great strength. If such bone is subjected to sufficient violence, fracture will result through an adjacent thinner juxta-articular segment.

REFERENCES

HARRIS, H. A.: Bone Growth in Health and Disease: The Biological Principles Underlying the Clinical, Radiological, and Histological Diagnosis of Perversions of Growth and Disease in the Skeleton. London, Oxford University Press, 1933.

PAYR, ERWIN: Gelenksteifen und Gelenkplastik. Teil 1. Pathologische Biologie. Pathogenese und pathologische Anatomie der Ankylosen. Klinik, Diagnostik und Anzeigestellung. Berlin, Julius Springer, 1934.

A METHOD OF ANCHORING KIRSCHNER WIRES

BY EDWARD N. REED, M.D., F.A.C.S., SANTA MONICA, CALIFORNIA

The accompanying drawings illustrate a method of anchoring the ends of Kirschner wires in tension bows, which has been found to be sure and effective, and also of simple, easy, and cheap construction.

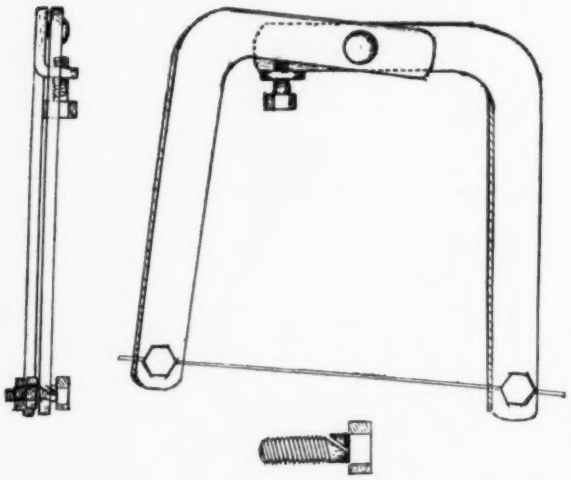

FIG. 1

The ends of the bows are drilled to take an ordinary machine cap screw. A screw, five-sixteenths of an inch in diameter and one inch in length, has been found to work well. The shoulder of the screw, between the head and the first thread, is sawed with a hack-saw diagonally from the outside to or a little past the center. By mounting two blades together in the hack-saw frame, a cut is made of sufficient width to accommodate the ordinary wire. (The author uses wires of a thickness of about fifty-four thousandths of an inch.) The wires are dropped into the slots in the cap screws and the nuts are tightened, using two wrenches. The slotted part of the cap screw is drawn down into the hole in the bow, which it fits snugly, and the wire is thereby locked so securely that no amount of tension can cause slipping. There is no need either for hardening of clips or for serrations to grip the extremely hard surface of piano wire. These locks can be made up in a few minutes at an expense of a few cents.

A COMMON CAUSE OF GENU VALGUM AND A SUGGESTION FOR ITS TREATMENT

BY R. M. YERGASON, M.D., F.A.C.S., HARTFORD, CONNECTICUT

For the past twelve or fifteen years, the author has frequently recommended the use of a home-made hobby-horse to correct the mild genu valgum which is so commonly seen in children and which is caused by riding an out-grown kiddie-car and pushing it along with the feet spread widely to the side. Numerous cures have been effected by this means in mild cases. The hobby-horse, shown in Figure 2, was made by the author and is not difficult to construct.

FIG. 1

The out-grown kiddie-car, which is too low, quickly causes genu valgum.

FIG. 2

A nail keg is a perfect body for the home-made rocking-horse, the use of which corrects genu valgum. No stirrups are used.

ERNEST MUIRHEAD LITTLE

JULY 26, 1854–OCTOBER 2, 1935

Orthopaedic surgeons all over the world will have read with regret of the death of Ernest Muirhead Little on October 2, 1935, at his home in Westminster at the age of eighty-one.

Born when orthopaedic surgery was in its infancy, Muirhead Little passed through the tenotomy phase and subsequently took a leading part in introducing Listerian principles in the open operative treatment of deformities. He qualified for the degree of Member of the Royal College of Surgeons in 1880 and became a Fellow of the Royal College of Surgeons in England in 1886. In 1888, he was appointed Surgical Registrar and later Surgeon to the National Orthopaedic Hospital, with which institution his surgical career thereafter became linked. In 1905, this hospital amalgamated with two other orthopaedic hospitals to form the Royal National Orthopaedic Hospital, and when the new building was opened Muirhead Little was appointed Senior Surgeon and Chairman of the Medical Board. In this capacity, he played a prominent part in the development of the hospital. By this time he had already become known internationally by his writings on congenital and paralytic deformities. His first publication, a small book entitled "Medical and Surgical Aspects of In-Knee (Genu-Valgum)", was written in conjunction with his father and appeared as early as 1882. From that time onward, he wrote steadily throughout his career and for many years rendered valuable service to the British Medi-

cal Journal by his writings on orthopaedic subjects and by the help which he gave to the editorial staff.

Early in the Great War he wrote a standard book on "Artificial Limbs and Amputation Stumps". In writing this book he incorporated the great experience he had gained during many years as Surgeon to the Surgical Aid Society and more recently as Surgeon to Queen Mary's Hospital for the war-disabled at Roehampton.

Even as long ago as 1876 he had acquired as a student a practical knowledge of military surgery, for he served in the Turco-Serbian war of that year and was awarded the Takova gold cross.

In what may be called clinical orthopaedics and the knowledge of its literature, Little was in his day almost unrivalled. He had a tenacious memory and could give references with amazing accuracy for particular papers in the literature; in this respect he was very approachable and would go to no end of trouble to satisfy the quest of those who appealed to him. He took great interest in the history of medicine and those who have read his "Glisson" will detect his literary gifts. His editing of the "History of the British Medical Association" for the Centenary Meeting of 1932 was widely commended.

Little received many professional distinctions. In 1894, he was elected a corresponding member of the American Orthopaedic Association. In 1913, when the International Congress of Medicine was held in London, he was Vice-President of the Orthopaedic Section, and the same year, on the formation of the Orthopaedic Subsection of the Royal Society of Medicine, he became its first President. In 1919, the British Orthopaedic Association also elected him as its first President, and, at the meeting of the British Medical Association in 1926, he was president of its Orthopaedic Section.

Muirhead Little was a man of natural charm and rare culture, beloved by his colleagues, his hospital patients, and all who knew him, and the profession has lost one of its most honest and sincere orthopaedic surgeons and a pioneer of singular modesty.

NOTE: *The Journal* is indebted to the *British Medical Journal* for the accompanying photograph of Mr. Little.

BRAINERD HUNT WHITBECK

JULY 20, 1877–MARCH 1, 1936

Brainerd Hunt Whitbeck died at his home in Bronxville, New York, March 1, 1936, after a long illness. He is survived by his widow, three sons, and one daughter.

Dr. Whitbeck was born in Rochester, New York, July 20, 1877. He attended St. Paul's School, Concord, New Hampshire, was graduated from Harvard College in the class of 1899, and from the College of Physicians and Surgeons of Columbia University in 1903. He served his internship in Bellevue Hospital.

During the World War he was an inspector in the Orthopaedic Service of the Eastern Division, and was commissioned a Lieutenant Colonel in January 1919. He was the first commander of the Leonard Morange Post, American Legion, Bronxville.

Dr. Whitbeck was Professor of Orthopaedic Surgery in the University of Vermont, and served for many years on the staff of the Hospital for the Ruptured and Crippled. He was Consulting Surgeon to the Roosevelt Hospital, Neponsit Beach Hospital for Crippled Children, Lawrence Hospital, Bronxville; Vassar Brothers Hospital, Poughkeepsie; and the Thompson Memorial Hospital, Canandaigua.

He was a member of the American Orthopaedic Association, the American College of Surgeons, the New York Academy of Medicine, and the Harvard Club.

All his life Dr. Whitbeck was handicapped by precarious health, but in spite of it he insisted on leading a most varied and strenuous existence. As his hospital appointments show, he travelled widely and almost continuously. Whenever possible he drove his car. Motoring he professed to be his favorite hobby, but it may be that he was thus making a virtue of necessity. He was a devoted husband and father, and took the keenest interest in following the careers of his boys in their college life, and in tennis, a sport in which they were exceptionally proficient. In fact, most of his enjoyments seemed to be of this vicariously domestic variety.

Dr. Whitbeck was one of the kindest of men, and the children in his various hospital services were devoted to him—always a good index of a man's character. He met the ups and downs of his professional career and the inroads of ill health with at least a perfect outward calm, although his nature was extremely sensitive. One who knew him for many years would like to say that he was a true gentleman—one of whom his family, his college, and his university might well be proud.

WILLIAM J. TAYLOR

1861–1936

Dr. William J. Taylor, a member of the American Orthopaedic Association since 1892, died at his home in Philadelphia on January 22, 1936 after a long illness, at the age of seventy-four.

He was graduated from the University of Pennsylvania Medical School in 1882. He very early developed an interest in surgery and was associated with Dr. Weir Mitchell. In 1887, he became assistant to Dr. W. W. Keen who was connected with the Philadelphia Orthopaedic Hospital and Infirmary for Nervous Diseases, and his experiences in this institution led him into the field of orthopaedic surgery. He was Professor of Orthopaedic Surgery in the Philadelphia Polyclinic Hospital from 1893 to 1895. He was also surgeon to the Orthopaedic Hospital for over fifty years and was affiliated with many of the larger hospitals of Philadelphia. He very early identified himself with the College of Physicians of Philadelphia and was its President in 1919, 1920, and 1921, and was most active in promoting the activities of this famous organization. In 1908 and 1909, he was President of the Philadelphia Academy of Surgery and continued a valued and active member of that organization until his death.

During the World War, Dr. Taylor saw active service in France at Base Hospital No. 10, and later as consultant to Medical Headquarters of the American Expeditionary Forces. At the time of his death, he was Lieutenant Colonel in the Reserve Corps.

Dr. Taylor was most highly esteemed by his associates not only because of his surgical ability and judgment but also because of the great friendship and genuine interest which he showed to those with whom he came in contact. Always ready to counsel and aid when occasion offered, he proved himself a real friend and, because of his basic knowledge of surgical principles, enriched by a very large and varied experience, his advice was safe and sane.

He stood for the highest in orthopaedic surgery and was always prepared to give the best in every instance. His pleasant and quiet personality was a marvelous asset in the recovery of his patients. He radiated cheer and confidence to them and thus secured their complete cooperation with his efforts in their behalf.

It does not fall to the lot of many surgeons to earn, win, and hold the esteem, confidence, and love of those with whom they come in contact as did Dr. Taylor. His loss will be felt by patients, friends, and associates, and his wise and stimulating influence and interest in the advance of medical and surgical knowledge will be greatly missed by the many associations and societies (local, national, and international) with which he was connected.

News Notes

The Fiftieth Annual Meeting of the American Orthopaedic Association will be held in Milwaukee, Wisconsin, May 18 to 21, under the presidency of Dr. Frederick J. Gaenslen. Headquarters will be at the Hotel Schroeder. Among the papers to be presented will be the following:

President's Address.
Dr. Frederick J. Gaenslen, Milwaukee, Wisconsin.

History of Fracture Treatment.
Dr. William Arthur Clark, Pasadena, California.

Posterior Dislocation of the Hip with Fracture of the Acetabulum.
Dr. Willis C. Campbell, Memphis, Tennessee.

Reconstruction of Injured Elbows in Children.
Dr. Richard B. Dillehunt, Portland, Oregon.

Fractures and Fracture-Dislocation of the Cervical Spine.
Dr. William G. Turner, Montreal, Quebec.

Treatment of Fractures of the Elbow, Particularly Intercondylar Fractures, by Means of Traction.
Dr. Rudolph S. Reich, Cleveland, Ohio.

The Inclination of the Pelvis and Acetabulum as a Constructive Factor in Slipped Epiphysis and Non-Union in Fractured Hips.
Dr. Lloyd T. Brown, Boston, Massachusetts.

Acute Osteomyelitis: Treatment in the Light of Recent Serological Findings.
Dr. D. E. Robertson, Toronto, Canada.

Septic Hips: A Study of End Results.
Dr. Carl E. Badgley, Ann Arbor, Michigan.

Analysis of Results of Early Treatment of Congenital Dislocation of the Hip by Manipulation and Osteoclasis for Anterior Distortion.
Dr. Arthur Krida, New York, N. Y.
Dr. Paul Colonna, New York, N. Y.
Dr. Francis J. Carr, Jr., New York, N. Y. (By invitation.)

Primary Point of Infection in Tuberculosis of the Hip.
Dr. Dallas B. Phemister, Chicago, Illinois.
Dr. C. Howard Hatcher, Chicago, Illinois. (By invitation.)

Treatment of Bursitis.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.
Dr. Paul Norton, Boston, Massachusetts. (By invitation.)

Bone Metabolism.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

Fascial Transplants in Infantile Paralysis and Other Conditions Involving Weakness of the Muscle Groups.
Dr. Frank Dickson, Kansas City, Missouri.

Correction of Paralytic Drop-Foot by Tendon Transplantation.
Dr. Leo Mayer, New York, N. Y.

Treatment of Giant-Cell Bone Tumors.
Dr. Henry W. Meyerding, Rochester, Minnesota.

Arthrotomies for Internal Derangement of the Knee Joint.
Dr. Paul P. Swett, Hartford, Connecticut.

Auscultation of Joints.
Dr. Arthur Steindler, Iowa City, Iowa.

The Inquiry on Articular Pain.
Dr. J. G. Kuhns, Boston, Massachusetts.
Dr. H. L. Weatherford, Boston, Massachusetts. (By invitation.)
Chronic Atrophic Arthritis.
Dr. Theodore A. Willis, Cleveland, Ohio.
Series of Fractures of Neck of the Femur United with Excellent Functional Results after Treatment by Means of Smith-Petersen Nail.
Dr. Lawson Thornton, Atlanta, Georgia.
Dr. Calvin Sandison, Atlanta, Georgia. (By invitation.)
The Wave Mechanics of Muscle Motion.
Dr. Eben J. Carey, Milwaukee, Wisconsin. (By invitation.)
Factors Influencing the Balance of the Foot in Walking.
Dr. R. Plato Schwartz, Rochester, New York.
The Occurrence of Abscesses from Hips That Are Firmly Ankylosed. Dr. Z. B. Adams, Boston, Massachusetts.

The next Congress of the **International Society of Orthopaedic Surgery** is to be held in Bologna, Italy, from September 21 through September 25, 1936, under the presidency of Prof. Dr. Vittorio Putti. The meeting will be opened by a General Assembly on the afternoon of the first day, followed in the evening by the President's Dinner. The next three days will be devoted to the presentation and discussion of papers. On the afternoon of the fourth day, the members will leave for Rome where, on the closing day, they will have an opportunity to visit the new Clinic of Orthopaedic Surgery and to observe various clinical demonstrations.

The Sixth **Sir Robert Jones Lecture** was presented on February 6, 1936 at the Hospital for Joint Diseases, New York City, by Dr. Frederick J. Gaenslen. His subject was "Fracture of the Neck of the Femur".

The next Congress of the **Deutsche Orthopädische Gesellschaft** will be held in Königsberg Pr. on August 28, 29, and 30, 1936, under the presidency of Prof. Dr. Lothar Kreuz. The principal subjects to be discussed are: "The Knowledge and Treatment of Talipes Calcaneus", "The Biology of Amputations", and "Pathological and Clinical Considerations of Acute Lumbago".

The Congress of the **Czechoslovakian Orthopaedic Society** is to be held in Bratislava on June 27, 28, and 29, under the presidency of Prof. Dr. Mikula. The principle subject of discussion will be "Inflammation of the Joints". Prof. Frejka will present a paper on the subject of "Conservative Treatment for Inflammation of the Joints". Prof. Mikula will speak on "Arthroplasties" and Prof. Zahradníček will talk on "Treatment of Fractures of the Neck of the Femur".

The fourth meeting of **La Réunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux** was held in Bordeaux on November 28, 1935. In opening the meeting, the President paid a tribute to the memory of Dr. Gourdon, calling attention to his efforts in promoting orthopaedic surgery and his remarkable contribution since the War to the rehabilitation of the maimed. He was also one of the founders of the Society. Sixteen communications on interesting subjects were presented by different members and guests. These papers will be found printed in full in the *Journal de Médecine de Bordeaux et du Sud-Ouest*, the issue of January 20, 1936.

The second examination given by the **American Board of Orthopaedic Surgery** was held in St. Louis on January 11, 1936. Eighty-four candidates were certified at this time. Approximately 10 per cent. of the candidates failed to meet the requirements of the Board at this examination. The next examination will be held in conjunction with the annual meeting of the American Medical Association, to be held in Kansas City on May 11, 1936. Further information may be obtained from Dr. Fremont A. Chandler, Secretary, 180 North Michigan Avenue, Chicago, Illinois.

The next meeting of the **International Society for Crippled Children, Inc.** is to be held in Budapest from June 29 to July 3, 1936, under the patronage of the Government of Hungary and the Municipality of Budapest. The meeting is to be held under the auspices of the International Society for Crippled Children and the Hungarian Society for the Crippled, and the chairman will be Prof. Dr. Michael Horvath, of the University of Budapest. There will be an informal social gathering on Sunday, June 28. On Monday evening, June 29, a reception will be given by the Hungarian Government and on Tuesday evening, June 30, there will be a reception by the Municipality of Budapest. An interesting program for this session has been arranged. Further information may be obtained from Mr. Paul King, President, 1066 Federal Building, Detroit, Michigan.

The slogan of the **National Tuberculosis Association** for 1935, "Fight Tuberculosis with Modern Weapons", was so effective that by unanimous consent it is to be repeated for the Early Diagnosis Campaign of 1936. Emphasis is placed on the value of the early discovery of tuberculosis and the necessity of the patient's seeking medical advice promptly. The wisdom of anticipating the onset of tuberculosis by pushing the fight nearer to its source is also stressed. Pamphlets and posters are available for giving wide publicity to this subject. The Association has continually endeavored to bring important information on this subject before the public, and has been largely instrumental in bringing about the marked diminution of the disease throughout the country.

Lord Nuffield, who has always been interested in the problem of the care of the crippled, has already contributed very generously to provide for the hospital equipment and treatment of these individuals in England, New Zealand, and Australia, with the special object of discovering and treating children attacked by some crippling disability. For a long time, Lord Nuffield has been anxious to help forward this work in Great Britain, in order that in every area suitable provision may be made for the early and adequate treatment of every child, adolescent, and adult in need of it. He has now presented the sum of 125,000 pounds to provide for the early and efficient orthopaedic treatment of cripples. The major portion of this sum will be allocated to a Lord Nuffield Central Fund which is to be applied at the discretion of the trustees during the next four or five years toward developing this project. Another part of this amount is to be devoted to the endowment of a Scholarship in Orthopaedic Surgery, to be tenable for two years at the Wingfield-Morris Orthopaedic Hospital, with a travel period of three months to follow. This most generous provision of Lord Nuffield's, which allows study in a well-organized orthopaedic hospital of the most modern design, should be attractive and of value to young surgeons who are to specialize in orthopaedic surgery.

The Fourth Annual Convention of the American Academy of Orthopaedic Surgeons was held in St. Louis, Missouri, on January 13, 14, 15, and 16, 1936, under the presidency of Dr. Frank D. Dickson.

Three morning and afternoon sessions were devoted to the presentation of scientific papers, including a symposium on "Bone Tumors" and another on "Fractures in and around the Elbow Joint". Orthopaedic clinics were held at five St. Louis hospitals on the morning of January 16.

There were thirty-two scientific exhibits and thirty-eight technical exhibits. Prizes for scientific exhibits were awarded by a committee consisting of Dr. Ludvig Hektoen, Chairman, Dr. Arthur Steindler, and Dr. Robert Terry. The Gold Medal was awarded to Dr. Henry Kessler, Newark, New Jersey, for his exhibit on "Cineplastic Amputation". The Silver Medal was awarded to Dr. Sherwood Moore, St. Louis, Missouri, for his exhibit on "Leontiasis Ossea Familiale Juvenile". The Bronze Medal was presented to Dr. Eugene W. Wolcott, Des Moines, Iowa, for his exhibit on "A Study of the Circulation in the Head and Neck of the Femur as Supplied through the Ligamentum Teres and Capsular Vessels". Certificates of Honorable Mention were awarded to Dr. Ralph K. Ghormley and Dr. A. E. Deacon, Rochester, Minnesota; Dr. G. Edmund Haggart, Boston, Massachusetts; Dr. John P. Lord, Dr. Robert D. Schrock, and Dr. Herman F. Johnson, Omaha, Nebraska; Dr. Leo Mayer, New York, N. Y.; Dr. Joseph E. Milgram, New York, N. Y.; and Dr. Austin T. Moore, Columbia, South Carolina.

The six radio talks given under the auspices of the Academy were as follows:

Physically Handicapped Children and Adults.
Dr. J. Archer O'Reilly, St. Louis, Missouri.

Progress in American Orthopaedic Surgery.
Dr. Melvin S. Henderson, Rochester, Minnesota.

Infantile Paralysis.
Dr. Philip Lewin, Chicago, Illinois.

Modern Treatment of Bone and Joint Injuries.
Dr. Frank D. Dickson, Kansas City, Missouri.

Bone Tumors.
Dr. Henry W. Meyerding, Rochester, Minnesota.

Fractures.
Dr. J. Albert Key, St. Louis, Missouri.

The Academy voted to hold its next Annual Meeting in Cleveland, Ohio, on January 11, 12, and 13, 1937.

The following officers were elected for 1936:

President: Dr. Melvin S. Henderson, Rochester, Minnesota.
President-Elect: Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Vice-President: Dr. W. B. Carrell, Dallas, Texas.
Treasurer: Dr. E. Bishop Mumford, Indianapolis, Indiana.
Secretary: Dr. Philip Lewin, Chicago, Illinois.

BRITISH ORTHOPAEDIC ASSOCIATION

The British Orthopaedic Association held its Annual Meeting in Manchester on October 25 and 26, under the Presidency of Mr. Harry Platt.

The opening morning was devoted to a discussion on three aspects of:

FRACTURES OF THE OS CALCIS:

I. *Economic Results*

A discussion of the subject was led by Mr. B. L. McFarland and Mr. W. J. Eastwood, of Liverpool, who were followed by Mr. J. P. Hosford, Mr. R. J. Furlong, and Mr. T. T. Stamm, all of London. The speakers were agreed that the final result depended on whether or not the subastragaloid joint was disorganized. If it was not involved, an excellent functional result ensued in the majority of patients. Where the joint surfaces were disturbed, permanent disability was liable to follow for two reasons: (1) the development of a painful arthritis; and (2) the weakness of the calf muscles consequent upon upward displacement of the posterior fragment of the os calcis. Experience had not shown that the type of treatment employed appeared to influence materially the ultimate function of the foot. Restoration as far as possible of the normal anatomy of the os calcis by the powerful skeletal-traction method advocated by Böhler of Vienna in the few cases

so treated had not permitted the patient to resume heavy labor any more successfully than had simple manual molding and fixation in plaster-of-Paris for several months. Nor had this method shortened the time in which the individual could return to lighter occupations.

II. *Results of Attempted Reduction in a Series of Recent Fractures*

By invitation of the Association, Dr. E. E. Myers, of Boston, Massachusetts, reviewed a series of thirty-three consecutive fractures involving the subastragaloid joint which had been treated in the Fracture Services of the Ancoats Hospital and the Manchester Royal Infirmary. These were divided into two groups. The first group comprised eighteen fractures in which an attempt had been made, with varying success, to restore the normal anatomy of the os calcis by powerful skeletal traction and compression. More than half of this group of patients were able to return to their original arduous duties without subjective symptoms and with no appreciable impairment of the function of the foot. The second group consisted of fifteen fractures treated only by manual manipulation and fixation in plaster-of-Paris. Of this group, only one-third of the patients were able to return to heavy work.

Dr. Myers emphasized two facts: (1) that the results were invariably better in the light, wiry type of individual; and (2) that in those patients in whom the best results had been achieved the subastragaloid joint was clinically ankylosed.

He concluded that a very definite advance in the treatment of these fractures had been made by attempts to restore the normal anatomy of the foot, and suggested that in certain cases, following a reduction, early arthrodesis of the subastragaloid joint might be expected to increase further the numbers of good functional results.

III. *The Treatment of Old Fractures*

Mr. R. Ollerenshaw, of Manchester, said that, if a two-year period was allowed to elapse before a final analysis of these fractures was made, the general results were not so disheartening. In reviewing a series of forty-five patients, in all of whom the fractures were more than three years old, he had found that thirty-four had returned to their original work. For those who continued to complain of pain, his routine was the manipulation of the foot into inversion and the application of a plaster-of-Paris cast for several weeks. A very small number of old fractures required a subastragaloid arthrodesis, but this procedure could not always be relied upon to produce complete relief of symptoms.

On the second morning several short papers were read, as follows:

Use of the Sub-Standard Kinematograph Films in Case-Recording
by Mr. R. Ollerenshaw, Manchester

The Mechanism of Bone Absorption
Histological Aspects — by Prof. S. L. Baker, Manchester
Roentgenological Aspects — by Dr. E. W. Twining, Manchester (by invitation)

Congenital Torticollis — by Mr. C. H. Gray, Manchester

Osteochondritis in Congenital Dislocation of the Hip
by Dr. M. F. Johnstone, Manchester

Fractures of the Internal Epicondyle of the Humerus
by Mr. H. O. Clarke, Manchester

The following officers were elected for the year 1936:

President: Mr. W. R. Bristow
Vice-President: Mr. T. P. McMurray
Treasurer: Mr. S. L. Higgs
Secretary: Mr. E. P. Brockman
Editorial Secretary: Mr. H. O. Clarke
Executive Committee: Mr. R. Ollerenshaw
Mr. A. Rocyn-Jones

At recent meetings of the Executive Committee of the **British Orthopaedic Association,** the following were elected to membership:

Honorary Members

Dr. J. Delchef, 34 Rue Montoyer, Brussels, Belgium

Prof. A. Maffei, 42 Rue de Livourne, Brussels, Belgium

Full Members

Mr. R. W. Butler, Grove Lodge, Cambridge

Mr. W. J. Eastwood, 69 Rodney Street, Liverpool

Associate Members

Mr. W. V. Anderson, Fraser House, Colinton, Midlothian, Scotland

Mr. William Barclay, 5 Murray Road, Huddersfield

Mr. W. Sayle Creer, The Craige, West Lane, Freshfield, Liverpool

Mr. James Dawson, The Nook, Keighley Road, Bradford, Yorks.

Mr. E. Bell Jones, 6 Gambier Terrace, Liverpool

Mr. R. J. Katrak, New Sitaran Building, Princess Street, Bombay, India

Mr. A. M. A. Moore, 89 Harley Street, London, W. 1

Mr. S. B. Morris, 7 Waiata Avenue, Remuera, Auckland, S. E. 2, New Zealand

Mr. R. P. Osborne, Park Hospital, Davyhulme, Manchester

Mr. T. B. Reid, Park View, Grove Hill, Middlesborough

Mr. David Trevor, 18 Devonshire Street, Portland Place, London, W. 1

Mr. W. E. Tucker, 62 Wimpole Street, London, W. 1

Mr. D. Wainwright, Mill Road Infirmary, Liverpool

The Spring Meeting of the **British Orthopaedic Association** is to be held in Brussels, April 22 to 26, 1936, with headquarters at the Palace Hotel.

Current Literature

DIAGNOSTIC ROENTGENOLOGY. Ross Golden, M.D., Editor. New York, Thomas Nelson and Sons, 1936. $20.00.

With the advent of the roentgen ray and the vast amount of knowledge which has resulted from each of the new methods of investigation, there has also come to the physicians employing these methods an increased responsibility in fitting themselves to use this information more accurately. In no branch of medicine in which investigations have been made and laboratory methods have been developed is it more important than in the field of roentgenology. Dr. Golden has emphasized the necessity of a broad foundation of medical education, training, and experience for those who occupy themselves especially with the interpretation of evidence as given by the roentgenogram. He calls attention to the error of using roentgenographic reports as a short cut in diagnosis rather than as corroborative evidence of clinical findings.

Dr. Golden has presented in this large book of 854 pages a most complete work on the subject of diagnostic roentgenology. He has divided the book into eleven chapters with the following subjects, which indicate the extensive scope of this volume:

The Roentgen-Ray Diagnosis of Diseases of the Skull and Intracranial Contents;
The Roentgen-Ray Examination of the Paranasal Sinuses and the Mastoids;
Radiology of the Chest;
Clinical Roentgenology of the Cardiovascular System;
The Roentgen-Ray Examination of the Digestive Tract;
The Roentgen-Ray Diagnosis of Diseases of Bones;
The Roentgen-Ray Diagnosis of Spinal Cord Tumors;
Roentgenologic Diagnosis of Diseases of the Urinary Tract;
Uterotubography;
The Use of the Roentgen Ray in Obstetrics;
The Radiology of Fractures.

In the preparation of this work, Dr. Golden has been aided by the following collaborators whose experience has particularly fitted them to speak with authority on this subject: Alexander Brunschwig, Cornelius G. Dyke, George W. Grier, Paul C. Hodges, Leopold Jaches, Howard C. Moloy, Dallas B. Phemister, Coleman B. Rabin, Samuel A. Robins, Hugo Roesler, Albert A. Shapira, Edward H. Skinner, Marcy L. Sussman, and Paul C. Swenson.

The scope of this book covers the use of roentgenology in practically all parts of the body. Each subject is described in detail and is fully illustrated by excellent photographs, roentgenograms, drawings, and charts. The plan has been followed of giving a descriptive clinical review of each subject, including the etiology, pathology, and in many cases the treatment. So frequently the information given by the roentgenogram is of such material aid in determining the course to be followed in the treatment of these cases that it is decidedly helpful to have a discussion of this relationship. These descriptions are excellent and help the reader to understand the interpretation of the roentgenograms.

The plan of supplementing the roentgenographic findings and illustrations with a complete explanation of the conditions which they illustrate, as well as the comprehensive scope, allows the volume to be used more for general reference than simply as a text-book on roentgenology. The book is published in an extensible form, so that other portions may be added at any time.

This volume will be found valuable by every practitioner of medicine and every surgeon.

THE PARATHYROIDS IN HEALTH AND IN DISEASE. By David H. Shelling, B.Sc., M.D. St. Louis, The C. V. Mosby Co., 1935. $5.00.

This monograph, written by a physician who is also a scientist, constitutes the finest and most comprehensive review of the normal and pathological physiology of the parathyroid glands that is to be found in the literature today. As has been stated in the preface, "The physiologists have concerned themselves with the problem of parathyroid extirpation and its effects on the nervous system; the chemists have studied the chemical changes in the blood and excreta which result from dysfunction of these minute bodies; the pathologists have investigated the changes which occur in the parathyroids in systemic diseases, as well as the changes which dysfunction of the parathyroids may produce in the other tissues of the body; and, last, the clinicians have contributed to the symptomatology of disease associated with parathyroid derangements. The scattered information from these various sources has rarely been molded together into an homogeneous whole. The several excellent periodic reviews on the parathyroids, such as those of J. B. Collip in *Physiological Reviews*, W. G. MacCallum in *Medicine*, and G. Hersheimer in Henke-Lubarsch's *Handbuch der speziellen pathologischen Anatomie*, have dealt, for the most part, either with physiology or with pathology, rather than with the subject as a whole. The less recent reviews have become obsolete, owing to the rapid progress which has been made in the past decade, especially in the chemical and clinical phases of the subject."

Dr. Shelling has succeeded in bringing up to date, in a concise form and with a style that is interesting and easy to follow, the knowledge that has been compiled by hundreds of physiologists and clinicians. He has further succeeded in tying together the great heterogeneous mass of published theories and facts into a composite statement.

The question which is often asked, "What is the present status of the parathyroid glands and their importance in clinical medicine?", can best be answered by referring those interested to this book. More than half of the book deals with the anatomy and physiology of the parathyroid glands with particular reference to hypoparathyroidism. The newer subject of hyperparathyroidism and osteitis fibrosa is adequately covered. There are sections in which the author expresses his opinions, as well as those of other workers, concerning the relation of the parathyroid glands to the other glands of internal secretion and to vitamin D.

This reviewer most enthusiastically recommends this monograph on the parathyroid glands to the physiologist, the pathologist, the chemist, the internist, the roentgenologist, and the surgeon. No student of endocrinology can afford to be without it.

THE RADIOLOGY OF BONES AND JOINTS. By James F. Brailsford, M.D., M.R.C.S. Ed. 2. Baltimore, William Wood & Co., 1935. $9.00.

Although only a year has elapsed since the appearance of the first edition of this book, so much progress has been made in many of the departments of radiology that the author has been able to supplement the material in the first edition by discussing many of the results of these researches of the past year. This second edition is dedicated to the memory of Sir Robert Jones.

The chapters on "Osteochondritis", "Bone Dystrophies", and "Spondylolisthesis" have been rewritten and a chapter on "Dental Radiography" has been added. The index has also been revised to enable the reader to find more readily the material desired.

In the second edition, the general plan of arrangement found in the first volume has been followed, — the descriptions of the roentgenographic appearance of the various conditions are accompanied by descriptions of the diseases and malformations which are illustrated by the roentgenograms. In the new chapters, the subjects are considered in a particularly comprehensive way; not only is there a complete description of the findings, but the conditions which are illustrated are discussed with relation to their etiology, pathology, and treatment. The book is wide in scope and is profusely illustrated by very excellent roentgenograms, and in many cases tracings from roentgenograms have been added to illustrate more clearly the conditions described.

The plan of including a discussion of the present status of many of the subjects which are illustrated, which is now being followed by many writers on this subject, contributes very largely to the value of a work of this kind; and this added information stimulates the constantly increasing interest in the study of radiology.

Dr. Brailsford is constantly augmenting our fund of knowledge on this subject and the present volume bears witness to his experience and painstaking study.

THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE PERIPHERAL ARTERIES. By Saul S. Samuels, M.D. New York, Oxford University Press, 1936. $3.50.

This volume of 350 pages is a simple, concise presentation of the modern methods for the diagnosis and treatment of peripheral-arterial diseases. It is based on the long experience of the author, who reports 350 cases of thrombo-angiitis obliterans with only one amputation. Each chapter is followed by a complete bibliography. New procedures and unproved opinions are given only a brief discussion; most of the treatise is reserved for the problems of the two major organic diseases.

The volume will be appreciated by those especially interested in arterial diseases because it includes the summation of a large series of cases successfully treated, with an orderly reference to the literature. It will be of far greater value, however, to the general practitioner, who will find the book so well written and explicit that he will gain such information as will enable him to recognize early cases of thrombo-angiitis obliterans and arteriosclerosis without the aid of special equipment. Apparently, the object of the author is to clarify the conception generally held by the profession and to present rational procedures of diagnosis and treatment on simple, conservative, and efficient lines.

Two full chapters are given to a general discussion of the subjective and objective symptoms of diminished peripheral circulation. One chapter is devoted to oscillometry.

Next, is the usual sequence discussion of thrombo-angiitis, followed by case reports. Much detail is given to diagnosis and treatment.

The other major organic obtructive disease, arteriosclerosis obliterans, is presented in the same manner.

The groups of conditions, such as Raynaud's disease, resulting from vasomotor imbalance are given less discussion in accordance with their clinical importance.

Some readers will not agree with the author's conclusions in every instance, but, for clearness in stating the essential facts and for application in the field of general practice, this volume is a valuable addition to medical literature.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales (Valencia), II, Núms. 19–24, 1935.
Anales de Cirugía (Rosario), I, No. 2, 1935.
Anales de Pediatría (Facultad de Medicina de Barcelona), II, Núm. 20, 1935.
Boletim da Secretaria Geral de Saúde e Assistencia (Rio de Janeiro), I, No. 3, 1935.
Boletines de la Sociedad de Cirugía de Rosario, II, Núms. 1–7, 1935.
Bulletin of the National Tuberculosis Association, XXIII, Nos. 1 and 3, 1936.
Children's Hospital of Winnipeg. Twenty-Seventh Annual Report. 1935.
Cleveland Clinic Quarterly, III, No. 1, 1936.
Journal of the Indian Medical Association (Calcutta), IV, Nos. 12 and 13, 1935; V, No. 3, 1935; V, No. 4, 1936.
Journal of South Indian Medicine (Madras), II, Nos. 3 and 4, 1935.
L'Action Médicale (Montréal), XI, No. 12, 1935.
Revista de Medicina (Buenos Aires), I, Núm. 2, 1935.
Roentgen Economist, IV, No. 2, 1936.
Wiener medizinische Fakultät. Programm des 57. Fortbildungskursus: Internationalen Fortbildungskursus über Fortschritte der Therapie bei inneren Krankheiten mit besonderer Berücksichtigung der Nachbargebiete. 1936.

EINE RÖNTGENOLOGISCHE STUDIE ÜBER ARTHRITIS ACROMIALIS (An X-Ray Study of Acromioclavicular Arthritis). K. Lindblom. *Acta Chirurg. Scandinavica*, LXXVII 174, 1935.

A review of the roentgenograms in two views of 419 acromioclavicular joints establishes the fact that hypertrophic arthritis of the acromioclavicular joint can be shown roentgenographically in many cases of shoulder pain. This arthritis is often the explanation of the shoulder pain. A single severe trauma is probably the most frequent cause of the arthritis.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

ON THE TREATMENT OF TUBERCULOSIS OF THE TALOCRURAL AND TALOCALCANEAL JOINTS. Robert Hanson. *Acta Orthop. Scandinavica*, VI, 19, 1936.

There were 110 cases of tuberculosis of the foot and ankle in 3,055 cases of surgical tuberculosis. The ankle joint alone was involved in fifty-three, the ankle and talocalcaneal joints in twenty-nine, the ankle, talocalcaneal, and talonavicular joints in sixteen, the talocalcaneal joint alone in eleven, and the talocalcaneal and talonavicular joints in one. Age and sex are tabulated and eleven illustrative cases are summarized.

Involvement of the posterior talocalcaneal joint is often secondary to that of the ankle joint, but may result from primary involvement of either the talus or calcaneum. The anterior talocalcaneal joint was spared in thirty-six cases of involvement of the posterior talocalcaneal joint, apparently because of the separation of the joints by the interosseus ligament.

Resection was performed in twenty-seven cases of tuberculosis of the ankle joint and is recommended rather than astragalectomy in adults. Astragalectomy is better in children. Conservative treatment was employed in thirty-six cases and has been successful, temporarily at least, in four.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

ZUR KENNTNIS DER SKELETTVERÄNDERUNGEN BEI DER SCHÜLLER-CHRISTIAN'SCHEN KRANKHEIT. (XANTHOMATÖSE SPONDYLOSE MIT PARAVERTEBRALER SCHATTENBILDUNG.) Skeletal Changes in Schüller-Christian Disease. (Xanthomatous Spondylosis with Paravertebral-Shadow Formation.) Gösta Jansson. *Acta Radiol.*, XVI, 59, 1935.

The author describes a case of Schüller-Christian disease which, besides the characteristic defects of the cranial and thigh bones, showed destruction of a thoracic vertebra. The xanthomatous spondylosis was accompanied by a paravertebral-shadow formation exactly resembling the gravitation abscesses occurring in tuberculous spondylitis. The production, in connection with xanthomatous spondylosis, of a roentgen shadow resembling that of a gravitation abscess is something which has never been observed before. In the author's opinion, it is due to a paravertebral accumulation of lipoid granulation masses.—*Lewis Cozen, M.D., Iowa City, Iowa.*

THE MALIGNANT TUMORS OF THE PERIPHERAL NERVES. Arthur P. Stout. *Am. J. Cancer*, XXV, 1, Sept. 1935.

This paper reports a careful study of the malignant tumors of the peripheral nerves. It contains an excellent bibliography and is fully illustrated with photomicrographs and photographs of gross specimens. The author reviews the literature and adds new cases from his experience. He goes thoroughly into the classification of the tumors and the clinical characteristics of the various types. He recognizes two groups of malignant tumors,—those which have the morphological characteristics of malignant fibroblastic tumors and those which are epithelial in type and reproduce in a recognizable form neuroectodermal structures. The majority of the former tumors occur in individuals suffering with von Recklinghausen's disease. The neuro-epithelial group of tumors is very rare and presents diverse histological features.

It is very interesting that these tumors present so little interference with motor nerves and that they so seldom need to be considered in the differential diagnosis of orthopaedic problems.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

TUMORS OF THE PERIPHERAL NERVES. Charles F. Geschickter. *Am. J. Cancer*, XXV, 377, Oct. 1935.

This paper is based on the material available for study at the Johns Hopkins Hospital laboratories and includes the benign as well as the malignant tumors of the peripheral nerves.

The impressive characteristic of these tumors is that they have such a very minor orthopaedic significance. Tumors of the cauda equina may give rise to pain strongly suggestive of sacro-iliac disease and are frequently accompanied by flaccid paralysis, with loss of reflexes. In general, however, the tumor is the presenting characteristic in these cases and impairment of motor function or pain suggestive of bone or joint disease is exceptional. A brief section deals with amputation neuromata without bringing out any new features. Individuals wishing to pursue study in these fields would do well to consult the original paper which is excellently organized and annotated.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

CHORDOMA: A STUDY OF 150 CASES. Roy E. Mabrey. *Am. J. Cancer*, XXV, 501, 1935.

This article reviews from a clinical standpoint all cases of chordoma reported to date and adds eight additional cases, bringing the total to 150. Chordoma is a rare and usually fatal tumor which arises from the foetal notochord, and the majority of the tumors appear in the sacrococcygeal region. The cranial chordoma is next most common, and there are also some rare instances of vertebral chordoma. The greater incidence in males raises the question of the etiological significance of trauma.

Pain is the most common symptom in all of these cases and tumor is the next most common observation. Rectal symptoms are fairly common in cases where the tumor is located in the sacrococcygeal region. Paralysis or weakness of the arms or legs may occur, especially in connection with the cases involving the vertebrae. Since the tumor arises in the nucleus pulposus, fracture of the vertebra and rupture of the intervertebral disc have to be considered in the differential diagnosis.

The benign giant-cell tumor, tuberculosis, osteoma, chondroma, and chrondrosarcoma also must be considered at times in the differential diagnosis. Roentgenographic examination usually shows a soft-tissue shadow with destruction of the bone. The lesion is not a bone tumor and proliferation is not to be expected. The presence of a painful swelling of long duration in the sacral region, coupled with an irregular defect in the sacrum, demonstrable by the roentgenogram, is suggestive of chordoma. A photomicrograph shows the characteristic large epithelial-like vacuolated cells which confirm the diagnosis.

Treatment is unsatisfactory from the standpoint of cure. In cases of vertebral chordoma, laminectomy may be desirable to relieve cord pressure. The tumors are very vascular and surgical removal is often hazardous. Radiation is not particularly effective in controlling the growth, although it sometimes relieves pain.

Metastases, involving chiefly the regional lymph nodes, liver, or lungs, have been found in a rather high percentage of reported autopsies.

The paper is well illustrated with roentgenograms, photomicrographs, and photographs of gross specimens. It presents numerous tables dealing with the distribution, age incidence, duration of symptoms, etc. There is a good bibliography of the recent literature.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

BONE METASTASIS IN CARCINOMA OF THE STOMACH. H. Dabney Kerr and Raymond A. Berger. *Am. J. Cancer*, XXV, 518, 1935.

The authors point out that bone metastasis from carcinoma of the stomach is relatively infrequent. The total number of cases showing bone involvement is usually assumed to be less than 6 per cent. In a review of 143 apparently authentic cases in the literature, to which they added five more from their own experience, the authors found

that the commonest sites of bone metastasis from carcinoma of the stomach appear to be in the spine, ribs, femur, sternum, and pelvis. Osteoblastic metastases are about as common as the purely destructive lesions. Bone metastases appear to be more frequent in relatively young patients. Some of the patients show an anaemia which cannot be distinguished morphologically from a primary type and which may show a large percentage increase of immature cells of the myeloid series.

The paper presents roentgenograms and photomicrographs and includes a very careful bibliography.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Artificial Fever Therapy of Gonorrheal Arthritis. Report of Thirty-One Cases. H. Worley Kendall, Walter W. Webb, and Walter M. Simpson. *Am. J. Surg.*, XXIX, 428, 1935.

During the past three years, the outlook for patients with gonorrhoeal arthritis has been enormously improved. This report is based on thirty-one cases in which several forms of treatment were used, including hot baths, cabinets with carbon-filament electric bulbs, electric blankets, diathermy, and radiothermy. The clinical results were essentially similar when the fever could be maintained over a sufficiently long interval. The apparatus used for fever induction and maintenance was for the most part the air-conditioned "Kettering hypertherm". The average set of air conditions to which the patient's body is subjected are: dry-bulb air temperature of 140 to 150 degrees Fahrenheit; relative humidity of 35 to 40 per cent., and air velocity of 425 cubic feet per minute. The elevation of rectal temperature to 105 degrees is usually obtained in forty minutes. During the treatment, two to four liters of sodium chloride solution (0.6 per cent.) is given by mouth to replace the chloride loss.

The *in vitro* thermal death point of fifteen strains of gonococci was determined at different temperature levels. At 102 degrees Fahrenheit, growth was not appreciably affected. At 104 degrees, about 99 per cent. of the organisms were killed by ten hours' exposure. At 105.8 degrees, 99 per cent. were killed by from four to five hours' exposure; the remaining 1 per cent. required from eleven to twenty-three hours. At 106 degrees, 99 per cent. were rendered non-viable in two hours, while the remaining 1 per cent. required five to twenty hours.

During the past four years, the authors have treated 383 patients and have given 2,844 fever treatments without injury to any person. Patients are given four to five treatments of five to seven hours' duration with a therapeutic range of 106 to 106.8 degrees Fahrenheit at intervals of three to five days. In 74 per cent. of the author's cases, the disease was polyarticular. Twenty-three patients had positive smears. Of the eight patients with negative smears, three had acute gonorrhoeal arthritis and five had chronic arthritis. Following the course of treatment, twenty-four patients showed a negative smear. The smears of seven patients were still positive, but in four of these cases the smears became negative in two weeks.

Of the nineteen patients with acute gonorrhoeal arthritis, the average improvement in joint function immediately following the fever treatment was 27.5 per cent.; in three patients, the joint restoration was complete. Of the twelve patients with chronic gonorrhoeal arthritis, the average improvement at the conclusion of the course was 62.5 per cent. In four cases, joint function was completely restored. At the present time, the average improvement in joint function in the acute cases is 98.5 per cent.; in the chronic cases, 88.3 per cent.—*Paul Siman, M.D., Iowa City, Iowa.*

Tuberculosis of the Shafts of Long Bones; Clinical and Roentgenological Study with a Report of Eight Cases. C. K. Petter and J. P. Medelman. *Am. Rev. Tuberc.*, XXXII, 285, 1935.

Of 4,896 patients admitted to Glen Lake Sanatorium, 275 had bone and joint tuberculosis, with or without pulmonary manifestations. Of this latter number, eight patients had tuberculosis of the shafts of the long bones. This type of lesion, therefore, is ex-

tremely rare. The authors believe that tuberculosis of the shafts of long bones is primarily destructive in the cancellous portion, becoming proliferative when the periosteum is approached. In the differential diagnosis of lesions in the shafts of long bones, tuberculosis, syphilis, and pyogenic osteomyelitis should always be considered.—*Clarence A. Ryan, M.D., C.M., Vancouver, B. C., Canada.*

ZUR BEHANDLUNG DER OSTEOMYELITIS IM KINDESALTER (Treatment of Osteomyelitis in Childhood). Max Langer. *Arch. f. klin. Chir.*, CLXXXI, 640, 1935.

Langer is very careful and conservative in the treatment of osteomyelitis. If nothing is found on the bone, only the soft tissues are incised. If the soft-tissue abscess is surrounded by a thick muscle mass, a rubber drain is inserted for from one to two days to prevent full closure. Otherwise, the skin edges are approximated by stitches placed at wide distances from each other. If the infected bone lies superficially, small incisions, one-half of a centimeter in length, are sufficient without the insertion of a drain. If the focus is close to the shoulder or hip joint, an extension bandage is applied. If other areas are involved, the neighboring joints are immobilized by plaster splints. Langer never uses circular plaster bandages. If sequestra have formed, they are surgically removed only if they present themselves in the sinus tract. The elimination is left almost entirely to nature. This method of treatment has been used by the author for the last four years and he states that during that time chronic osteomyelitis, with all its sequelae, has become a rare disease in his hospital.

During these four years, forty-two patients with osteomyelitis were admitted to the hospital; seven of these patients died in the first week. In twenty-two cases, all of the sinuses healed within two years. The roentgenograms did not reveal signs of activity. Thirteen patients did not return to the hospital.—*Ernst Freund, M.D., Venice, Florida.*

RÖNTGENDIAGNOSTIK DER ERKRANKUNGEN IN DER ZWISCHENWIRBELSCHEIBEN (Roentgenographic Diagnosis of Diseases of the Intervertebral Discs). N. A. Podkaminsky. *Arch. f. klin. Chir.*, CLXXXII, 352, 1935.

The author reviews the different pathological changes in the intervertebral discs with anatomical and roentgenographic manifestations and discusses them under five headings.

1. Pathology of the cartilaginous plate of the intervertebral disc. The cartilaginous plate between disc and vertebral body is of great importance under normal conditions in the growth of bone; under pathological conditions, it becomes of even greater significance. The author mentions especially the herniation through the cartilaginous plate into the vertebral body, the so called Schmorl nodules. They are frequent, being found in 38 per cent. of all cases examined. They can be demonstrated *in vivo* by x-ray only if a zone of reactive osteosclerosis has formed around the body. Of interest is the differential diagnosis between congenital and traumatic joint bodies. The presence of other traumatic lesions (fractures of apophyses, ruptures, ligaments, etc.) and the localization of the lesion may be of help. If cartilaginous bodies are found in the cervical spine, they are usually due to trauma. If there is good function of the spine, the presence of cartilaginous bodies does not indicate disability.

2. Diseases of the annulus lamellosus. The intervertebral disc proper has vessels up to the end of the growth period. This shows that a number of infectious diseases (sepsis, grippe, typhus, tuberculosis, etc.) may affect the disc through the blood stream. After the age of twenty-five, most of the changes in the intervertebral disc are due to degeneration resulting from insufficient nutrition by diffusion. The degeneration of the disc may be followed by secondary vascularization with fibrosis. Podkaminsky thinks that he can demonstrate degeneration and fibrosis of the intervertebral disc in the roentgenogram. The lateral portion shows, on one side or both sides, a homogeneous dark

shadow without any signs of spondylarthritis. These changes can apparently be demonstrated only in the lumbar spine. In such cases of fibrosis of the intervetebral disc, the lumbar spine shows stiffness, and low-back pain is present. In older patients, this x-ray symptom is due to the wear and tear on the tissue. In some cases, the fibrosis of the disc may be only the first sign of an ossifying process which leads to "discosis spongiosa", as the author calls it. In such cases, the roentgenogram shows at the site of the intervertebral space spongy bone without alteration of the vertebral bodies. As far as the calcification of the intervertebral disc is concerned, Podkaminsky does not agree with Bársony and Koppenski, who differentiated two types of calcification: a central one in the nucleus pulposus and a peripheral one in the fibrous annulus. He thinks that the differentiation is too schematic. He believes that calcification, discosis petrificans, may occur wherever there is degeneration. Inflammatory processes, disturbed calcium metabolism, and trauma are predisposing factors. In cases in which degeneration is combined with considerable destruction, compression of the disc takes place (discosis atrophicans or discitis destructiva). Narrowing of the intervertebral space is the roentgenographic sign. The converse, increased intervertebral space (discosis hypertrophicans), is present in cases of osteoporosis.

3. Diseases of the nucleus pulposus. The nucleus pulposus is usually the first site of degeneration and Podkaminsky advances the following theory of spondylarthritis deformans. Due to a disturbance in the function of the synovial enzymes present in the nucleus pulposus, colloids become precipitated. The lymph sinuses become more or less extensively occluded; the nutrition of the fibrous ring is impaired, causing its degeneration and loss of elasticity. The changes in the bone are secondary and reactive.

4. Paradiscosis. Besides homogeneous ossification of the intervertebral disc, ossification of the lateral portion may take place in the form of a half moon, the convexity turned outside. The lateral margin consists of a layer of perichondrium which becomes displaced by pressure. Instead of talking of bridges, Podkaminsky suggests the term "peridiscosis semilunaris". These changes are found mostly between the fourth and fifth lumbar vertebrae.

5. Discoligamentosis. In some diseases of the intervertebral disc, the surrounding ligaments also participate. Podkaminsky suggests the term "discoligamentosis", which may be either petrificans or ossificans. He thinks that with the progress of our knowledge his classification will have to be enlarged, but at present he considers it as the most complete.—*Ernst Freund, M.D., Venice, Florida.*

SERUM CALCIUM, INORGANIC PHOSPHORUS AND PHOSPHATASE ACTIVITY IN HYPERPARATHYROIDISM, PAGET'S DISEASE, MULTIPLE MYELOMA AND NEOPLASTIC DISEASE OF THE BONES. Alexander B. Gutman, T. Lloyd Tyson, and Ethel B. Gutman. *Arch. Int. Med.*, LVII, 379, Feb. 1936.

The calcium and inorganic-phosphorus content of the serum and the serum-phosphatase activity were determined in four cases of hyperparathyroidism, seventy-six cases of Paget's disease, six cases of multiple myeloma, and forty-five cases of neoplastic disease of the bones. The relevant data from the literature were summarized.

In classic cases of hyperparathyroidism, there is hypercalcaemia, hypophosphataemia, and increased blood-phosphatase activity. A similar state of affairs was encountered only in an occasional case of carcinoma with advanced skeletal metastases. Although studies of the blood may be of great value in confirming or excluding the diagnosis of hyperparathyroidism, the interpretation of their significance without careful consideration of the clinical and roentgenographic aspects of the case may lead to grave error.

In Paget's disease, the calcium and inorganic phosphorus of the serum may remain within normal limits in spite of extensive skeletal changes. An increase in blood-phosphatase activity, however, is demonstrable in almost all cases of polyostotic Paget's disease and remains remarkably constant for years. It is probably a result rather than a cause of the disease.

Hypercalcaemia may occasionally be present in cases of multiple myeloma. The inorganic phosphorus of the serum is within normal limits except when renal insufficiency causes retention of phosphates. The serum-phosphatase activity is usually essentially normal. The presence of hyperproteinaemia may be of value in the diagnosis of multiple myeloma.

The occasional occurrence of hypercalcaemia in cases of extensive osteolytic metastases in the bones may lead to confusion with hyperparathyroidism or multiple myeloma. Similarly, the increased serum-phosphatase activity, observed particularly in association with diffuse osteoplastic metastases in the bones, may be confused with that found in cases of Paget's disease.—*Clark W. Heath, M.D., Boston, Massachusetts.*

ZUR FRAGE DER SPONDYLOLYSIS. F. Reischauer. *Beitr. z. klin. Chir.*, CLXII, 64, 1935.

The investigations carried on by Schmorl and his pupils have given further support to the theory that spondylolysis is a congenital anomaly; as a result, Meyer-Burgdorff's conception of spondylolysis as an acquired lesion has lost considerable ground. Meyer-Burgdorff is also against the purely traumatic origin of spondylolysis, but he states that there are in the lordotic lumbar spine areas of anatomical variations in the intra-articular portion.

If one considers the question of spondylolysis from a clinical standpoint, two facts have to be mentioned which do not endorse the theory that congenital anomaly is the sole cause of spondylolysis. Bilateral separation is always present in cases of spondylolisthesis and it is also prevalent in cases of simple spondylolysis; whereas in the embryo and in infants the separation is almost always unilateral. This is not surprising because embryologically the lysis does not represent simply a maldifferentiation or retarded development, but is the anomaly of an anomaly (two bony nuclei in the lateral portion of the neural arch, instead of the normal one, and lack of fusion of the bony nuclei).

The second point is the frequency of spondylolysis. If the cause of the separate neural arch were purely congenital, one would have to expect that this condition could be demonstrated roentgenographically throughout life. The frequency of spondylolysis has to remain the same in different age groups; there can be a decline with the years only if secondary union should take place. In studying Schmorl's material, Junghanns found that spondylolysis was present in from 1 to 2 per cent. of the cases, and that males and females were almost equally affected. In a selected group of compensation cases, in which male patients predominated, Meyer-Burgdorff found the occurrence of separate neural arch to be very frequent, and this anomaly was present in 20 per cent. of the patients with injuries of the vertebral spine. Warner found this defect in 12 per cent. of the cases. From these figures alone, it would appear that there is much evidence in support of the theory of the acquired origin of spondylolysis. The typical localization of the separation in the interarticular portion cannot be taken as proof of the congenital origin because, in people doing hard manual labor, this portion is under greater stress than all other parts of the spine. If one compares the forces acting upon the posterior arch with its strength, the disproportion becomes manifest, especially in hard-working people like miners who work in the forward flexed position.

Two thousand kidney plates were studied, one-half of which were of cases in which the patients were under forty years of age. In this group, no case of separate neural arch was found; in the other 50 per cent., five cases of separation of the third and fourth lumbar vertebrae were found. (The fifth lumbar vertebra was not taken into consideration because of the flat plates.) The positive cases were all found in men doing hard manual labor.

Reischauer believes that these separations are due to an insidious process of bone transformation similar to Deutschländer's metatarsal fractures and other instances of Looser's zones of bone transformation. The congenital origin of some cases cannot be

denied, but the higher frequency of the occurrence of the anomaly in older people, especially in the hard-working class, favors the theory that spondylolysis is an acquired lesion.—*Ernst Freund, M.D., Venice, Florida.*

OSTEO-ARTHRITIS OF THE HIP-JOINT. T. P. McMurray. *British J. Surg.*, XXII, 716, 1935.

Such great ingenuity has been shown in the classification of osteo-arthritis of the hip joint that, in many of the classifications, it is almost impossible to recognize what is after all a very common condition. The classification generally accepted is the simplest of all, the infective or toxic type, and the traumatic type.

In a study of eighty-nine cases, the author reports that the average age of onset for the bilateral cases was fifty-three years; in the unilateral group, it was thirty-four years. A large proportion of the unilateral cases were preceded by injury to the hip.

The roentgenographic appearance is usually typical, with a loss of joint space, atrophy of the bones, and a rim of osteophytic outgrowths lying around the articular margins of the acetabulum. In unilateral cases, there is usually some distinct alteration in the shape of the head of the femur, while in the bilateral cases the head remains normal in shape.

In toxic or infective arthritis there is the problem of generalized infection, while in arthritis of one hip, whether there be an infectious process present or not, it is probable that trauma or an alteration in the joint mechanism was the exciting cause, and the fear of spread of the condition is not present to the same extent.

The different methods of treatment are considered in detail and the author comes to the following conclusions: Manipulation may produce a relief of symptoms and increase movement temporarily. Arthroplasty is the ideal operation, but at present our methods and techniques fail to secure any real benefit for the patient and the operation is a failure. Arthrodesis removes the pain and deformity and greatly increases the stability of the joint, but it is a very extensive procedure and if unsuccessful results in a great increase of strain on the lumbar spine and sacro-iliac region. The bifurcation operation of Lorenz is simple, of short duration, and, if performed correctly, leads to relief of pain and deformity with no loss of stability and does not cause strain on the lumbar regions.—*Paul Siman, M.D., Iowa City, Iowa.*

THE HISTORY OF PLASTER-OF-PARIS IN THE TREATMENT OF FRACTURES. J. K. Monro. *British J. Surg.*, XXIII, 257, 1935.

At least 4,000 years ago, starch was being used in linen to give a stiffening effect for splinting.

Three phases in the use of plaster are recognized. Cheselden (1688–1752) and Larrey (about 1798) concentrated their attention on the bone. Later Seutin (1834) and Lucas-Championnière gave prior consideration to the soft parts. Movements of joints and massage were emphasized and light, portable starch apparatus was used. It remained for Krause and Böhler to point out that efficient splinting of the fracture would allow the limb to be kept constantly in use.

Matthysen in 1852 first described the use of powdered plaster-of-Paris in treating fractures. When the time came for the removal of the bandage, this was done by wetting the plaster and unwinding the bandage.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

A FURTHER NOTE ON THE DEVELOPMENT OF CYSTS IN CONNECTION WITH THE SEMILUNAR CARTILAGES OF THE KNEE-JOINT. Robert Ollerenshaw. *British J. Surg.*, XXIII, 277, 1935.

Twenty cysts in the semilunar cartilages of the knee joint are reported,—eighteen in the external cartilage and two in the internal cartilage.

Cartilage cysts may arise from the free border of the semilunar cartilage and project into the joint, producing locking symptoms and followed by effusion into the joint.

The writer believes that the smaller cysts are lined with endothelium.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

SPONDYLITIS ANKYLOPOEIETICA (SPONDYLITIS OSSIFICANS LIGAMENTOSA). F. Campbell Golding. *British J. Surg.*, XXIII, 484, Jan. 1936.

Rigidity of the spine from this condition may appear in any part, but the Marie-Strümpell type in the lumbar spine and the Bechterew type in the upper dorsal spine are the forms about which most has been written.

Infection is commonly believed to be the cause of the condition, although proof is lacking. Occupation, trauma, or strain do not appear to play a part. Males are most commonly affected, and the average age is the early thirties. The writer believes that the lesions occur first in the sacro-iliac joints; the smaller joints of the spine are then involved, with secondary involvement of the vertebral bodies and the ligaments. There is extensive connective-tissue formation with final ossification of the articular surfaces.

The writer, a roentgenologist, has collected the roentgenograms of ninety-one patients suffering from spondylitis ankylopoeietica. In every case, the sacro-iliac joints were involved, while in thirty-three cases, the sacro-iliac joints were involved, but the spine was unaffected. The symptoms in these latter patients were the same as the early symptoms in the more advanced group.

All patients gave a history of muscular and joint pains long before the onset of spinal rigidity. The author believes that the condition should be recognized earlier, that the sacro-iliac joints are the earliest clues to the diagnosis and to the degree of severity of the disease.

In some patients, the lesions burn themselves out and cease to give symptoms. Other patients get periods of relief from no treatment. Very little is said about the active treatment, but this omission is excusable because the article has been based on the roentgenographic study of the condition.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

FURTHER OBSERVATIONS ON THE DISTURBANCE OF METABOLISM CAUSED BY INJURY, WITH PARTICULAR REFERENCE TO THE DIETARY REQUIREMENTS OF FRACTURE CASES. David P. Cuthbertson. *British J. Surg.*, XXIII, 505, Jan. 1936.

The writer has previously called attention to the marked loss of body nitrogen, sulphur, and phosphorus in the urine of patients who have had severe traumatic injuries. The present paper deals with experimental work to prevent this loss.

In patients suffering from fractures of the long bones, it was found that the ingestion of a diet rich in protein and high in caloric value modified the usual loss of protein in the form of nitrogen. There was, however, no effect at the height of the catabolic process, occurring on from the sixth to the tenth day. Massage, manipulation, and the addition of meat extractives or the use of diets high in caloric value but with average protein had no effect on the usual loss.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

ISOLATED DISLOCATION OF THE BASE OF THE FIFTH METACARPAL. Norman Roberts and C. Thurstan Holland. *British J. Surg.*, XXIII, 567, Jan. 1936.

Four cases of isolated dislocation of the fifth metacarpal are recorded. But one other case has been reported previously. All were of traumatic origin. There were two types of displacement,—an extreme degree of outward displacement and a less extreme inward and forward displacement. Displacements of the latter type may be reduced easily, but continuous traction for four to six weeks is required to maintain the position. When the metacarpal is displaced outward across the palm, open operation may be necessary.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

THE PATHOLOGY AND TREATMENT OF JOINT SPRAIN. Leo J. Miltner, C. H. Hu, and H. C. Fang. *Chinese Med. J.*, XLIX, 521, 1935.

The authors have covered the subject of sprain rather carefully and have done considerable research work. They define joint sprain as a disturbance of a joint due to trauma, with the involvement of the ligaments and surrounding tendons, without fracture or dislocation. They describe two types,—mild and severe.

The mild type involves only the ligament, while the severe type involves cartilage and periosteum as well.

Their research work was done with rabbits, in which disturbances of the knee joints were produced.

In the mild type of sprain, they observed increase in amount and elasticity of the synovial fluid, hemorrhage into the loose periarticular fluid, early proliferation of fibroblasts, and fibrosis. The severe type showed also a disturbance of the articular cartilage with resulting arthritis.

The treatment advocated by the authors consists of (1) complete immobilization by cast; (2) removal of cast for physiotherapy, including heat, massage, and active and passive motion. When the pain and swelling subside, gradual weight-bearing is permitted.—*Carl Ruhlin, M.D., Iowa City, Iowa.*

DIE ISOLIERTE SYPHILIS DER KNIESCHEIBE (Isolated Syphilis of the Patella). H. R. Paas. *Deutsche Ztschr. f. Chir.*, CCXLIV, 452, 1935.

The literature of the last twenty years contains only four cases of this rare condition.

The author reports the case of a female, twenty-nine years old, with a positive Wassermann, who had never been treated. In the spring of 1931, pain was noted over the anterior surface of the patella; there was no history of trauma. Swelling of the knee joint and weakness of the knee were evident. The symptoms subsided and recurred several times.

In December 1932, the patient was admitted to the hospital. There were no general luetic signs. Swelling, redness, and exquisite tenderness were noted over the left patella. Inflammatory capsular changes around the patella were also observed. The roentgenographic examination was negative. Six months later, there was definite apposition of the periosteal bone with sharply outlined osteophytes. Under antiluetic treatment, the condition improved in a very short time.

From his observations in this case and the reports in the literature, Paas gives the following description of the clinical picture of lues of the patella. The involvement of the peripatellar soft tissues and the anterior portion of the joint capsule is pathognomonic. The other parts of the joint are only rarely involved. The onset is insidious; the course, chronic. The clinical diagnosis is not difficult if the possibility of luetic infection is considered at all. Of differential diagnostic importance is the fact that the subchondral region remains free. The roentgenogram shows the characteristic periosteal reaction. Atrophy is practically absent.—*Ernst Freund, M.D., Venice, Florida.*

THE ETIOLOGY OF CHRONIC ARTHRITIS. Chester S. Keefer. *New England Med. J.*, CCXIII, 644, 1935.

The author classifies arthritis as follows: degenerative arthritis, commonly called osteo-arthritis or hypertrophic arthritis; and rheumatoid arthritis, commonly called infectious or atrophic arthritis.

Although the actual etiology of the arthritides is unknown, the author offers the following as the most likely theories.

Degenerative arthritis is due to injuries, excessive wear and tear, or trauma to the articular surfaces. There are three possible theories in regard to the etiology of rheumatoid arthritis.

1. The unitarian theory in which both the rheumatoid and degenerative types are thought to be due to the same etiological agent or groups of agents. The factors which determine the type of arthritis are trauma, focal infections, menopause changes, and

habits of the patients. This is thought to be true by many authorities, as there are so many mixed types of arthritis pathologically.

2. Infectious theory. This is thought possible because of the inflammatory symptoms and the fact that there are often found positive agglutination and precipitation reactions to hemolytic streptococci. This theory has also three possibilities within itself: (a) metastasis from a focal infection; (b) toxins absorbed from a focus of infection; (c) reactions of bacteria or their end products on some sensitized tissue.

3. The eclectic theory in which there is considered an imbalance of the nervous, gastro-intestinal, and peripheral nervous systems. Gastro-intestinal disorders are commonly found with a decreased acidity, but the author does not feel that there is any definitely convincing etiological background connected with it. Very seldom does one find vascular changes in a synovium in the joints. There is rarely any connection between Raynaud's disease or scleroderma and rheumatoid arthritis. The author does not believe that there are any results obtained by sympathectomy.

In conclusion, the writer states that, although there are no definite etiological facts, there will be a better understanding of the etiology as soon as there is a better understanding of the typing of the disease.—*D. M. Fuiks, M.D., Iowa City, Iowa.*

THE IMPORTANCE OF TRUNK MUSCLES AS EVIDENCED BY POOL WORK. C. L. Lowman. *Physiotherapy Rev.*, XV, 123, 1935.

The author stresses the value of the pool in the discovery of muscle weakness about the trunk, which cannot adequately be determined on the bed or examining table. Five reasons why the pool is of value are discussed:

1. It promotes the use of trunk muscles even while they are in a somewhat painful condition and influences the drainage of the cord where oedema might still be present.
2. It prevents disuse atrophy.
3. It allows a more adequate examination of the trunk in all planes.
4. It permits early movement of the trunk without danger.
5. It makes possible the early recognition of trunk weakness which aids in the prevention of spinal deformity.

While the patient is in the pool the special areas to be examined are the neck, thorax, abdomen, pelvis, and lower back. A number of muscles that are weakened are listed with their specific functions and the deformity which will result if they are neglected. The necessity of a careful check-up every six months over a period of three years is stressed. Also, one should not congratulate himself on a mild case until the patient has been tested in the pool for mild back weakness, 5 per cent. of which will result in deformity.—*Carl Ruhlin, M.D., Iowa City, Iowa.*

LES LÉSIONS TRAUMATIQUES DES LIGAMENTS CROISÉS DU GENOU (Traumatic Lesions of the Crucial Ligaments of the Knee). Leemans. *Presse Méd.*, XLIII, 1409, 1935.

The author believes that the unique function of the crucial ligaments is the prevention of excessive anteroposterior motion of the tibia on the femur. He considers De Rocher's "*signe de tiroir*" as characteristic but not pathognomonic of rupture of the crucial ligaments. He states that of fourteen cases reported by himself and others the sign was present in eleven and absent in three. He notes, however, that the sign may occasionally be present in the absence of a rupture of the crucial ligament and he attributes this to stretching of the ligament. On the other hand, he admits that rupture of the ligament may occur in the absence of the sign. He disagrees with the opinion expressed by others that the "*signe de tiroir*" occurs only when injuries to the crucial ligaments are associated with rupture of the lateral ligament. In support of this belief, he states that he has seen the sign in cases where the lateral ligament has been absolutely intact. On the other hand, he has not seen the sign in those cases in which unsatisfactory suture of the lateral ligament and abnormal lateral mobility have been noted after using the incision of Tavernier.—*Henry Milch, M.D., New York, N. Y.*

OSTÉOCHONDRITE DISSÉQUANTE DE LA HANCHE (MALADIE DE KOENIG). (Osteochondritis Dissecans of the Hip.) Albert Mouchet. *Presse Méd.*, XLIII, 1483, 1935.

The author takes advantage of the opportunity presented by a case report to discuss osteochondritis dissecans of the hip. He notes that the condition is at best rather unusual, that it is a disease of young adult life, and that it is characterized as follows: clinically, there is pain, a limp, or stiffness in the hip with limitation of motion, especially abduction and internal rotation in the hip; roentgenographically, the characteristic finding is that of a sequestrum at the upper pole of the head of the femur, close to the insertion of the round ligament. The condition is to be differentiated from that seen in the supernumerary ossicles about the cotyloid foramen. It is also to be differentiated from osteochondritis of the hip, Legg-Calvé disease, which is found only in young children.

No definite etiology has been described for the condition. Among the causes which have been suggested are: a single trauma, repeated minimal trauma, antecedent deformations of the head of the femur, tuberculosis, syphilis, and constitutional dyscrasias. The author expresses the opinion that gonorrhoea might occasionally be considered responsible.

Operation in the early stage may disclose nothing more than an area of softened cartilage. In the later stage, a true sequestrum will be found to have separated from the head of the femur. As in the knee joint, the treatment is operative and consists in removal of the joint mouse in order to prevent the development of a disabling arthritis of the hip.—*Henry Milch, M.D., New York, N. Y.*

DU TRAITEMENT DES OSTÉOMES (Treatment of Osteomata). J. S. Phelip and Dillensger. *Presse Méd.*, XLIII, 1499, 1935.

The authors express the opinion that osteomata are benign tumors of slow evolution, local growth, and traumatic origin, which cause local functional trouble. They consider that the trauma may be either single or repeated and that the direct result of this trauma is the formation of a hematoma which does not disappear, but which undergoes a gradual connective-tissue transformation. They are of the opinion that the transformation occurs in three stages which may be recognized roentgenographically. In the first stage, there is a large tumefaction and the roentgenogram is negative. This is the period of hemorrhage. In the second stage, the large tumefaction is present, but the roentgenogram shows signs of only a small calcium-containing neoplasm. In the third stage, the calcium-bearing area is practically of the same extent as the clinical tumor. The third stage represents the end stage in the development, while the two earlier stages represent the condition in the process of evolution. In these two earlier stages, operative intervention is contra-indicated, as well as massage or any other form of manipulative treatment. X-ray therapy alone should be employed during the first two stages and should consist of about ten to twelve radiations in a period of six to eight weeks. When the roentgenogram shows that the third stage has been reached, operation may be undertaken. By means of a gouge, the tumor should be excised completely and a portion of the normal bone should be removed. Thereafter, a short period of x-ray therapy is desirable.—*Henry Milch, M.D., New York, N. Y.*

LA RÉACTION DE FIXATION DANS LA TUBERCULOSE OSTÉO-ARTICULAIRE AU MOYEN DE L'ANTIGÈNE DE BESREDKA (Compliment Fixation in Osteo-Articular Tuberculosis by Besredka's Antigen). Kurt Meyer and Mme. Froyez-Roederer. *Presse Méd.*, XLIII, 2120, 1935.

The complement fixation by means of Besredka's antigen has been shown to be positive in 90 per cent. of the cases of pulmonary tuberculosis. Mozer and Fried found it to be positive in only 70 per cent. of the cases of progressive articular tuberculosis and in only 36 per cent. of the cases of regressive tuberculous arthritis.

In their series of cases the authors employed a new egg antigen prepared by Prof. Besredka. The work was carried on in two hospitals,—one for ambulant patients and

one for bed-ridden patients. With but slight modification, the technique was that employed by Besredka and described by Rubinstein. Three hundred and twenty-two reactions were studied. Of these, 124 were in patients with tuberculous lesions; fifty-two were in patients considered cured; and 146 were in non-tuberculosis patients used as controls. The authors divide the known tuberculous patients into age groups as follows: (1) up to six years of age; (2) between six and sixteen; (3) over sixteen. In general, they have found that the reactions tend toward a higher percentage of positives in the older age group than in the younger age group. In the older age group, the percentage of positives ran as high as 88, while in the total group of 124 individuals, the average was only 76.6 per cent. positive. In the non-tuberculous group of 146 patients, positive reactions were obtained in six or 4.1 per cent.

It appears that the test is more certainly positive in Pott's disease of the spine and in tuberculosis of the hip than in other types of osteo-articular disease. The authors are of the opinion that, in the presence of a positive reaction, they can state with certainty that there is an active process present. However, the negative reaction would be of value in excluding the presence of tuberculosis only in patients over the age of sixteen. In view of the fact that the percentage of positive results apparently diminishes with the duration of the cure, even in adults, the authors believe that the test may have some prognostic significance. This, however, is being studied further.—*Henry Milch, M.D., New York, N. Y.*

La maladie de Volkmann. Rétraction ischémique des muscles fléchisseurs des doigts. Pathogénie. Traitement. (Volkmann's Contracture. Pathology and Treatment). Raphaël Massart. *Rev. d'Orthop.*, XXII, 385, Sept. 1935.

In this article, written at the request of the Société Française d'Orthopédie, a comprehensive review of the present-day knowledge of Volkmann's contracture is recorded. It is pointed out that the condition is an evolutionary disease, starting with a necrotic muscular lesion and resulting in localized ischaemia and fibrosis which lead to vasomotor troubles and all the picture of Volkmann's contracture. There are three main causative factors: bone injury, too tight apparatus, and hemorrhage into tissue. Trauma of reduction may at times be the initial insult. Though the condition may occur in the absence of splinting, it is wrong to neglect this factor. In the acute form, with the vasomotor disturbances and nerve ischaemia, vascular troubles are of the first order. Injury to the blood vessels, not a hematoma, causes the absent radial pulse and the cold anaesthetic hand. The signs come on during the first hours and the damage occurs early, not late. Early and liberal operation is indicated. There is a chronic form in which the characteristic signs develop late, after a few weeks or months. The ischaemia and paralysis eventually develop with fibrosis of the muscles and adjoining tissues. If taken in time, something can be done for this group of patients,—sympathectomy and cutting of the arteries. If instituted too late, the above treatment does not suffice. The reaction is not reversible. Then there remain only the reconstructive procedures of the orthopaedic surgeon.—*Stephen G. Jones, M.D., Boston, Massachusetts.*

End Results of Leg Lengthening. G. Bruce Stephenson and Herbert A. Durham. *Southern Med. J.*, XXVIII, 818, Sept. 1935.

This report is based on seventeen cases. In two cases, lengthening of the femur was done, and in fifteen cases, lengthening of the tibia and fibula was carried out. In each case, the shortening was the result of poliomyelitis. None of the patients was under twelve years of age.

The technique and the apparatus are described in detail. With the type of apparatus used, frequent roentgenograms are not necessary; thus the danger of delayed union is avoided. The time required for lengthening is fifteen to twenty-five days. The lengthening apparatus is left on for from four to five weeks. A cast is then applied, followed by the use of a walking caliper.

In each case solid union was obtained in six to eight months. The minimum tibial

lengthening was one and three-fourths inches; the maximum, two and three-fourths inches. One femur was lengthened two and three-fourths inches; the other, three and one-fourth inches.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

SYNOVECTOMY OF THE KNEE JOINT IN CHRONIC ARTHRITIS. Solomon D. David. *Southern Med. J.*, XXVIII, 867, Oct. 1935.

The author reports ten cases in which eleven synovectomies were performed. The results were as follows: excellent, in nine cases; fair, in one case; and failure with ankylosis, in one case. The patients were carefully selected and the end results seem to justify the operation. Conservative methods should always be tried first, but they should not be persisted in too long.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

OPEN REDUCTION FOR FRACTURES AND DISLOCATIONS: INDICATIONS AND METHODS. Howard R. Mahorner. *Southern Med. J.*, XXVIII, 993, Nov. 1935.

Open reduction is the method of election in cases of fracture of the patella or of the olecranon with wide separation of the fragments, depressed fractures of the skull, and fracture of the neck of the femur in the aged. In the latter type, fixation is obtained by wood screws.

Open operation is also indicated in cases of fracture or dislocation which cannot be satisfactorily reduced by other methods, as well as in cases of malunion and non-union. One-fourth of the cases requiring open reduction are due to faulty initial treatment. The Lane technique diminishes the incidence of infection. Prolonged immobilization gives better end results than the early removal of splints and the use of physiotherapy, except in fractures into the joints and in elderly people.—*F. G. Hodgson, M.D., Atlanta, Georgia.*

WELL LEG TRACTION AS AN AID IN THE CORRECTION OF SOME STEREOTYPED ORTHOPEDIC DEFORMITIES. J. Warren White. *Southern Med. J.*, XXIX, 45, Jan. 1936.

Besides the employment of this apparatus in fresh fractures the author has found other uses.

After a hip fusion it is of value in maintaining abduction; only minimal traction is applied. The apparatus also aids in correcting lateral curvature of the spine by maintaining a tilted position of the pelvis. It is also used to correct adducted hips which cannot be corrected following manipulations or osteotomies, in spite of extensive myotomies and capsulotomies. It is of particular value in cases of poliomyelitis with bilateral hip flexion; however, care should be taken not to dislocate the adducted hip. This apparatus is also of great aid in cases of acute suppurative arthritis, especially in desperately ill patients and as an immediate postoperative dressing of an arthroplasty of the hip.

In many cases of pathological dislocation of the hip reduction will take place spontaneously—that is, without manipulation—when this apparatus is used. It also permits contracted scars to be stretched. This apparatus may be used in reverse—that is, to cause pressure instead of traction—and may be employed to insure good approximation after resection of the knee. Too much pressure should not be used, as it has been found by Key to be harmful.

The disadvantages of this apparatus are also mentioned.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*